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THE REAL AND APPARENT POSITIONS OF HALLEY'S COMET DURING ITS PERIOD OF GREATEST IMPORTANCE.

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FOR POPULAR ASTRONOMY.

Halley's comet, the most famous object in the history of cometary astronomy, is nearing its period of greatest brilliancy.

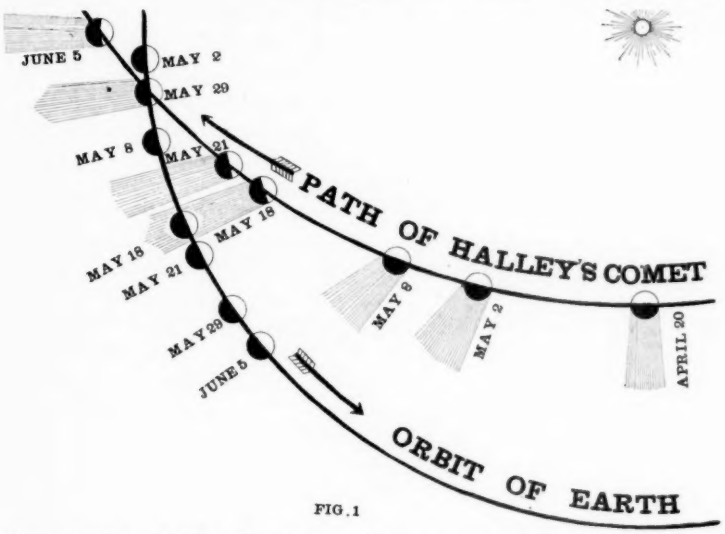

FIG. 1

The month of May is the most important time of the present return of the comet. During this time it will be visible to the naked eye.

It may be of interest to know just when and where to look for the comet. The accompanying diagrams are graphic representations of the comet's motion through space. Figure 1 shows the real path and Figure 2, the apparent path of the comet. For clearness' sake seven principal dates have been taken and are represented in both diagrams. The reader can easily supply for himself the remaining dates and thus have a

complete picture of the comet's course during the entire month.

The first diagram represents the *real* path of Halley's comet. All the circles showing the various orbits of the planets are omitted. The chart gives only the relative and real positions of the Earth, the Sun and Halley's comet. The circular curve indicates the Earth's path around the Sun. The elliptic curve traces the comet's journey in space.

The first position of importance in the diagram, is the one for April 20th. On this day the comet will be in *perihelion*, its nearest approach to the Sun. It will then be only fifty-five million miles from the Sun, corresponding to a little more than half the distance between Sun and Earth.

The next position of interest is that of May 2nd., when the comet will be nearest to Venus. It will be as close to this planet as it will be, later on, to the Earth. Venus at that time will be a morning star; the comet also will then be seen in the morning. Venus is about the size of the Earth. The view therefore of the comet near Venus will be an interesting one. Since the conditions of size and proximity of the Earth and Venus are similar, it will give us an idea of the appearance of the Earth when the comet will be near it.

May 8th is another important date. On that day the comet will be at its greatest distance or elongation to the right or west of the Sun. The Earth's position for the same date is marked on its orbit.

The most interesting day is May 18th. This date has been emphasized in the diagram. It is the day on which the Earth will pass through the comet's tail. The Earth will move in one direction, the comet speeding on in the opposite. The head of the comet will then be only 14,000,000 miles from the Earth. The tail itself will most probably extend beyond the Earth. The passage through the tail will be about five hours.

May 21st is the day when the comet is expected to be seen at its best. It will then be visible as a bright object in the evening sky.

The position which the comet occupies on May 29th is the same as the Earth's position about four weeks previous to that date. If the comet had anticipated its present return by about a month, the Earth and the comet's head would have crossed each other. Since the comet's path at that point is south of the plane of the Earth's orbit, the comet would have passed on, below the Earth.

On June 5th the comet and the Earth are represented as

separating. It is about this time that the comet grows fainter and becomes less conspicuous.

In Figure 2 the comet is represented as it appears, viewed from the Earth. To obtain a clear conception of the apparent motion of Halley's comet, we must call to mind the fact that the Earth is revolving on its axis and at the same time is moving in its orbit, and that the comet has a motion of its own. These three elements must be taken into consideration. Due to the Earth's rotation on its axis, the Sun and stars and comet appear to rise in the east and set in the west. Hence Halley's

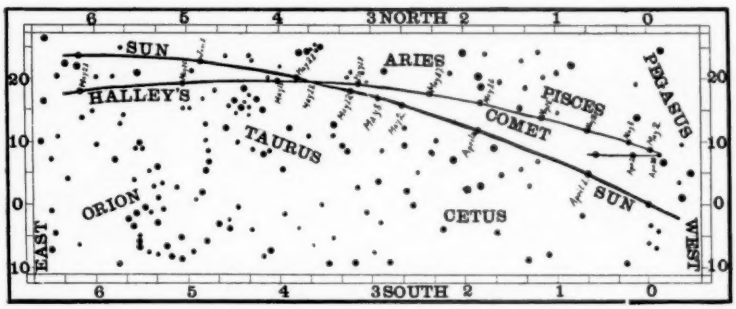

FIG. 2.

comet rises and sets just as the Sun and stars rise and set. Due to its own motion in its path and the Earth's motion in its orbit, the comet will rise earlier or set later every day. The combination of these motions results in the apparent motion of the comet as we see it when we look at the heavens. Figure 2 is a representation of the resultant of all these motions.

The constellations through which the comet appears to pass during the month of May are given in the chart. In reality the comet is travelling through the solar system, a portion of space where the Sun is the only star it meets, millions and millions of miles from the groups of stars through which it appears to pass. Since, however, the comet has the same direction from us as these stars, it appears to move through these constellations.

The line representing the apparent path of the comet is marked on the chart. The seven principal positions represented in Figure 1, are especially emphasized in Figure 2, showing the apparent positions of the comet during these seven stages of its flight through space. The Sun's path is represented and the various positions of the Sun for these dates are carefully mark-

ed. The north and south, the east and west directions are indicated. The numbers above and below, from 0 to 6 are the hours of right ascension ; the small spaces between the various hours are the 20 and 40 minute-marks. To the right and left, the numbers 10, 0, 10, 20, are the degrees of declination.

In the first chart we saw the "where" and "when" of the comet as it really is in space. The second chart shows us the apparent "where" and "when" of the comet.

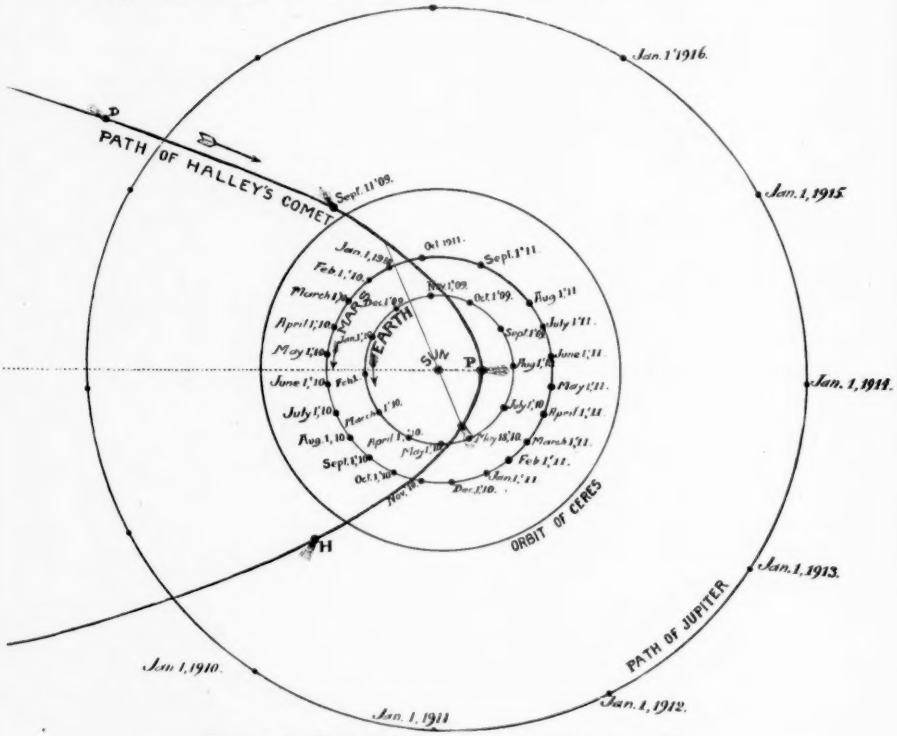

FIGURE 3. THE PRESENT RETURN OF HALLEY'S COMET.

On May 2nd the comet is represented in Figure 2 as being in the constellation of the Fishes, right ascension $23^h\ 53^m\ 38^s$ and declination $8°\ 12'$. The time when the comet will be visible is determined in the following manner. When the comet is to the right or west of the Sun on the diagram and also in the sky, it rises and sets before the Sun and hence is visible only in the the morning before sunrise. When it is to the left or east of the Sun it is visible only as an evening star. On May 2nd the comet

is to the west of the Sun, and is therefore seen in the morning, about two hours before sunrise.

On May 8th the comet is still in Pisces, right ascension $0^h\ 11^m\ 21^s$, declination 9° 50′. Being to the west of the Sun it appears as a morning star, a little more than two hours before sunrise.

On May 18th the comet is in Aries right ascension $3^h\ 7^m\ 19^s$, and declination 18° 51′.

On May 20th the comet will be seen in the constellation of Taurus; right ascension $5^h\ 3^m\ 23^s$ and declination 19° 8′.

The comet is now to the left or east of the Sun, hence on the last date mentioned the comet will be seen in the evening, setting about one hour later the Sun.

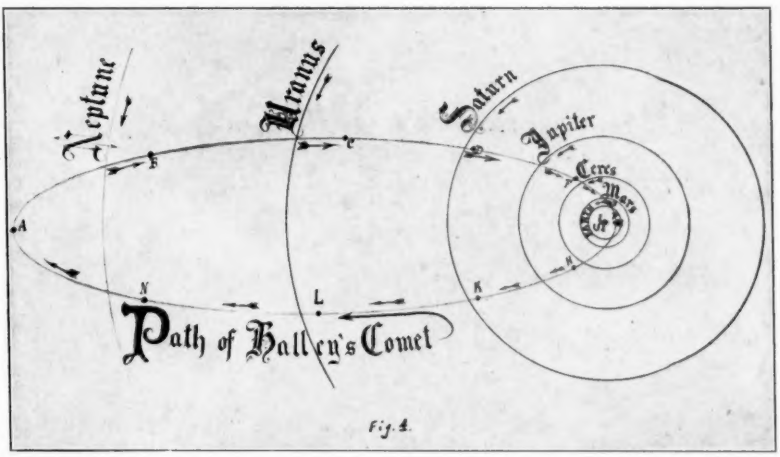

FIGURE 4. HALLEY'S COMET AFTER PRESENT RETURN.

The turning point for the rising and setting of the comet is about May 18th. Before this date the comet rises earlier than the Sun, and will therefore be seen as a morning star; after this date it sets later than the Sun and will hence be visible as an evening star.

To give a complete idea of all the important events in the entire journey of Halley's comet we add Figure 3 and Figure 4.

Figure 3 represents the relative positions of Sun, Earth, Mars, Jupiter and Halley's comet. On the path of Halley's comet the point *D* is the position which the comet occupied when the search for the comet began in 1909. The position marked September 11, 1909, is the place where the comet was situated when Professor Max Wolf of the Heidelberg Observatory, dis-

covered the comet, taking a picture of the approaching visitor.

In Figure 4 we look into the future, viewing the comet during its wanderings for the next 75 years. At *H* the comet, after its present visit, is beginning its long journey toward the orbit of Neptune. The points *K*, *L*, *N*, represent the wanderer approaching the orbits of Saturn, Uranus and Neptune. In the year 1948 the comet will have reached the point *A*, its aphelion position. It has then completed half its journey round the Sun, being then farthest removed from the center of the solar system. *B*, *C* and *D* represent the comet passing below the orbits of Neptune, Uranus and Saturn. The point *F* shows the position of Halley's comet in 1984 when the "new generation" will begin to search for the approaching famous historic comet.

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THE ORBITS OF METEORITES.

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Any investigation of this subject must be based principally on the hour and the date of the observed fall. As the result of an examination of several of the more important catalogues of meteorites, only two have been found which give the former of these quantities. These are Dr. Huntington's "Catalogue of all recorded Meteorites" published in the Proc. Amer. Acad. 1887, **23**, 37, and Dr. Farrington's Catalogue of Meteorites of the Field Columbian Museum, Publication 77. The former of these being the more extensive, has been employed in the present investigation.

In Table I, relating to stony meteorites, the local time in hours is given at the head of the columns, 0^h indicating noon, and the months at the left hand. It has not been found necessary to discriminate between the different days of the month, and indeed a table of that character has been published already on page 280 of POPULAR ASTRONOMY for 1909.

The numbers in the body of the table represent the number of meteorites that fell at any specified hour during any month. The totals are given in the last column, and also at the bottom, the lowest line giving the totals for periods of two hours.

Of the five iron meteorites mentioned in the catalogue, whose

hour of fall is known, two fell at 3^h, one at 6^h, one at 9^h, and one at 16^h. Another iron meteorite which was seen on August 1, 1898, fell at Quessa, Spain, at 9^h. Meteoritenkunde Cohen **3**, 304.

TABLE I.

DATES AND HOURS OF FALL.

Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Jan.	1			2	2			1	1													1	1	1	10
Feb.	3	1		2	2						1		1			1			1					1	13
Mar.					3	2	1															1		1	8
Apr.	1		1	1	3	1		1		1		1					1								11
May	1		2	1	1	4	2	2		1		1		1			1	1		1	2		2		23
June	4			2	1	2	1		3	3		1							1	1	3		1		23
July	1			2	1		1	2		2	1										1				11
Aug.	3				1	4			1				1		1			1				1		1	14
Sept.	2		1	1		4	1				1					1			1	2			1		16
Oct.	2			2	3														1	1	3	1	2		14
Nov.	1		1		3	1	4			1			1						1				1		15
Dec.			1		1				1	1					1				1		1	1	1	1	11
Total	19	5	11	13	28	9	9	5	9	4	4	0	4	0	3	2	1	5	6	3	10	5	9	5	169
	24		24		37		14		13		4		4		5		6		9		15		14		

Let Figure 1 represent the Earth as seen from the direction of the north pole of the celestial equator, the shaded portion representing the night side, and the numbers indicating the hours. With the circumference as the zero, let us plot in polar co-ordinates the numbers taken from the last row in the table. Connecting these points, we shall obtain the irregular broken line bounding the figure. The two small arrows indicate the direction of the Earth's rotation, and the large arrow in the center, the direction of its motion in its orbit.

Although falling stars and fireballs move both in direct and retrograde orbits, it is probable that only these fireballs revolving in direct orbits which are not too steeply inclined to the ecliptic, ever reach the Earth's surface, and become meteorites. This is because the others are destroyed by the heat due to their high velocities in passing through the upper layers of the Earth's atmosphere. Thus, although much more numerous than any

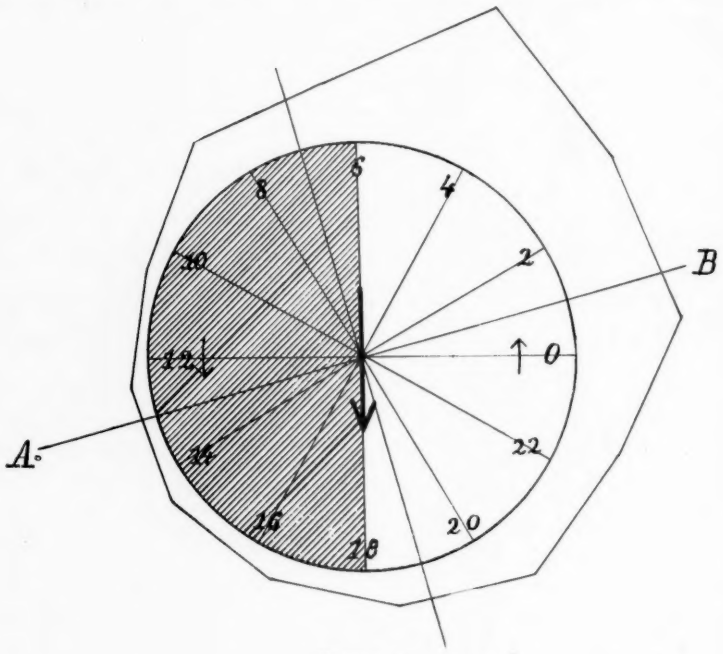

FIGURE 1.

other meteors, not one of the Leonids or Perseids has ever been seen to strike the ground.

Moreover, meteorites moving in retrograde orbits would fall almost wholly between midnight and noon, as is shown by the figure and would be readily recognized by their very high velocities relatively to the Earth. No such phenomenon has been observed. In point of fact, among the stony meteorites, two of the best known instances of high velocity were those that fell at Knyahinya, Hungary, and Amana, Iowa Co, Iowa. The former fell at 5^h, the latter at 10^h, and was then moving in an easterly direction. Both of these meteorites were therefore mov-

ing in direct orbits. The former weighed 660 lbs. and had a volume of about 4 cu. ft., but it buried itself in the soil to a depth of 11 feet. The latter weighed about 700 lbs., and moved northerly 112 miles and easterly 47, in ten seconds, or at a speed of 12 miles per second relatively to the Earth's surface. This high speed was due therefore chiefly to its large northerly component, indicating a highly inclined orbit. Professor H. A. Newton in the *Amer. Journ. Sci.*, 1888, **136**, 1 has shown that out of 116 meteorites a very great majority were certainly moving in direct orbits, most of them inclined at less than 35° to the ecliptic.

If all meteorites before their fall were moving in direct orbits, then those whose fall is observed between noon and midnight, as shown by Figure I, must overtake the Earth, and be moving faster than it. On the other hand those observed between midnight and noon must by overtaken by the Earth, and be moving more slowly than it. Any variation from this rule implies a highly inclined or very eccentric orbit. The speed with which a body moves at a given distance from the Sun depends only on the length of the major axis of its orbit. Consequently the orbits of those meteorites which fall between noon and midnight lie mainly outside the orbit of the Earth, while the orbits of these which fall between midnight and noon lie mainly inside of it. The perturbations due to the Earth would not appreciably affect these conclusions, but would slightly increase the number of collisions, and the striking velocity in all cases.

A glance at the figure shows that more meteorites overtake the Earth than are overtaken by it. We must not rely too much on the curve given in the figure, however, because it depends to a very appreciable extent on the general habits and characteristics of the human race. Outside of the great cities, throughout the greater part of the civilized world, the middle of the working day is one o'clock, and about as many people are likely to be outdoors throughout the year at seven in the morning as at seven at night. The irregular character of the curve is obviously due in part to the fact that there are few observers during the night time. Considering the number of observers as symmetrical about the line AB, it is clear that the number of meteorites, both during the day and night, is greater above that line than below it. The sum of the six radii above the line, taken from the table is 96, the sum of the six below it 73. The ratio is therefore practically 4 to 3. This is strikingly different from the hourly curve for falling stars, where the

latter half of the night is in excess, and to the extent of 2 to 1. Whether the maximum of the curve would coincide with 6^h if we could eliminate the human equation, we cannot say, but we shall see later that it looks as if it would.

Since those meteorites that fall between midnight and noon are moving more slowly than the Earth, and therefore in smaller orbits, we conclude that three-sevenths of the stony meteorites at all events are not associated with cometary orbits. As the others generally show no greatly preponderating speeds, it is doubtful if they are related to comets either. Apparently the stony meteorites form a belt of intersecting orbits, very like those of the asteroids, their mean distance from the Sun being about equal to that of the Earth. In this connection, it is interesting to note that Newton, in the paper already mentioned, concludes that in very few instances are their perihelion distances less than one half that of the Earth's orbit. An inspection of his results shows further that the perihelia increase appreciably in numbers as the Earth's orbit is approached. This implies that the eccentricity of these orbits is small, resembling that of the planets rather than the comets.

As shown by the last column of the table, there is a well marked maximum in May and June, but the distribution throughout the rest of the year is fairly uniform, no minimum appearing in November and December. Twenty-seven per cent fall during May and June, or 1.6 times as many as we should naturally expect. To explain this maximum we must have recourse to an examination of the individual orbits. For aid in this research, I am much indebted to the family of the late Professor Newton, who permitted me to examine the individual records on which he based his conclusions. In describing my results I shall make frequent use of a word coined by him, but which is not at present in general use. The point in the heavens from which a body is coming he calls its "quit." The position as computed directly from the observations is "apparent," but if corrected for the motion of the Earth in its orbit it becomes "absolute." "Apparent quit" as applied to a meteor shower is equivalent to the more usual term "radiant."

Newton's results are graphical, the graphical process being as he points out far superior to the analytical one for investigations of this character, which do not permit of the highest precision. The results consist chiefly of nine charts of the whole sky in stereographic projection, each chart giving the approximate location of the absolute quits of a dozen or more meteorites.

The reduction from the apparent quits he made on the supposition that the orbits were all parabolic. As he himself points out at the end of his paper, it would have been more accurate had he assumed elliptical orbits. Had he done so, the quits would have approached nearer to the quit of the Earth. This would, in no way, have invalidated his results, nor those which the writer will draw from his work, but would, on the other hand in some ways, have made them more striking.

Newton had intended to publish his results in detail himself, but he did not live to do so. Measures have been made from his charts, and the dates and hours of the falls ascertained when possible. The results of this, one of his most important investigations are now published for the first time in Tables II, and III. Of his 116 orbits, two were found to be duplicates, of one the date of fall is now known to be very uncertain, and six were associated with iron meteorites.

In what follows let S represent the position of the Sun on the celestial sphere, q the meteorite's absolute quit, and Q the quit of the Earth. The meteorites are arranged in the tables in the order of the days of the year, the first column giving a consecutive number, the second the name of the meteorite, the third the year of the fall, the fourth the date, the fifth the hour, the sixth the angle qS, the seventh the angle qQ, the eighth the latitude of the quit, and the last the complement of the angle qS.

TABLE II.

STONY METEORITES.

No.	Name	Year	Date	Hour	qS	qQ	q	Comp.
					°	°	°	°
1	Hassle	1869	Jan. 1	0.5	66	26	+ 6	24
2	Pultusk	1868	3	7	84	6	+ 4	6
3	Warrenton	1877	3	—	102	89	+77	12
4	Renazzo	1824	15	8.5	160	72	− 7	70
5	Cynthiana	1877	23	4	83	23	+23	7
6	Bécasse	1879	31	—	70	20	− 2	20
7	Alessandria	1860	Feb. 1	23.8	99	18	+15	9
8	Mòcs	1882	3	4	73	68	+62	17
9	Nanjamoy	1825	9	12	108	85	+70	18
10	Amana. Iowa Co.	1875	12	10.2	104	26	−21	14
11	Little Piney	1839	13	3.5	108	19	− 6	18
12	Alfianello	1883	16	3	117	41	+30	27
13	Linn Co.	1847	24	14.8	60	71	+55	30
14	Parnallee	1857	28	0	86	33	+34	4
15	Villanova	1868	28	22.8	124	104	+51	34
16	Salles	1798	Mar. 8-12	6	119	29	− 7	29
17	Pennyman's Siding	1881	14	3.5	80	14	+10	10
18	Alais	1806	15	5	90	47	+46	0
19	Djati-Pengilon	1884	19	—	133	43	− 2	43
20	Vernon Co.	1865	25	21	120	49	+34	30
21	High Possil	1804	Apr. 5	—	109	75	+65	19
22	Doroninsk	1805	6	5	56	37	+13	34
23	Toulouse	1812	10	1.5	116	33	+20	26

No.	Name	Year	Date	Hour	$q\,S$	$q\,Q$	q	Comp.
					°	°	°	°
24	Erxleben	1812	15	4	94	12	−11	4
25	Gütersloh	1851	17	8	123	47	+30	33
26	l'Aigle	1803	26	1	89	77	+78	1
27	New Concord	1860	May 1	0.8	86	17	−17	4
28	Krahenberg	1869	5	6.5	109	20	+ 5	19
29	Monte Milone	1846	7	21.5	92	30	+30	2
30	Forsyth	1829	8	3.5	82	34	−33	8
31	Estherville	1879	10	5	50	40	− 2	40
32	Kaande	1855	11	3.5	110	30	+22	20
33	Sevrukovo	1874	11	11.8	104	120	+57	14
34	Butsura	1861	12	—	112	24	− 8	22
35	Canellas	1861	14	1	38	89	−38	52
36	Orgueil	1864	14	8	70	22	+ 9	20
37	Gnadenfrei	1879	17	4	90	1	− 1	0
38	Tysnes	1884	20	—	89	70	+70	1
39	Stannern	1808	21	18	83	173	0	7
40	Slavetic	1868	21	22 5	90	10	+10	0
41	Cléquérec	1869	22	10	137	47	0	47
42	Gopalpur	1865	23	6	95	24	−24	5
43	St. Mesmin	1866	29	15.3	100	15	+ 9	10
44	Buschoff	1863	June 1	19.5	124	90	+57	34
45	Angers	1822	3	8.5	120	36	+19	30
46	Richmond	1828	3	20.5	81	15	+10	9
47	Japan	1741	8	—	82	25	+24	8
48	Knyahinya	1866	9	5	85	32	+38	5
49	Uden	1840	11	22.5	79	16	+11	11
50	Chateau Renard	1841	12	1.5	34	75	−30	56
51	Jonzac	1819	12	18	90	29	+29	0
52	Juvinas	1821	15	3.5	90	0	0	0
53	Kusiali	1860	15	17	88	30	+30	2
54	Siena	1794	16	7	120	52	+38	30
55	Ställdalen	1876	27	23.5	86	15	+13	6
56	Vago	1668	—	—	85	6	+ 5	5
57	Tabor	1753	July 3	8	55	41	+21	35
58	Lasdany	1820	12	5.5	98	10	0	8
59	Dhurmsala	1860	14	2.5	70	82	+68	20
60	Tieschitz	1878	15	1.8	26	96	+26	64
61	Cereseto	1840	16	19.5	48	45	−10	42
62	Vendome	1872	23	5.5	86	7	− 5	4
63	Gross Divina	1837	23	23.5	71	20	− 4	19
64	Barbotan	1790	24	9	82	15	+12	8
65	Aldsworth	1835	Aug. 4	4.5	55	37	− 7	35
66	Petersburgh	1855	5	3.5	103	20	+16	13
67	Pillistfer	1863	8	0.5	66	31	+20	24
68	Bethlehem	1859	11	—	34	60	+17	56
69	Shytal	1863	11	—	86	8	+ 7	4
70	Mern	1878	29	—	4	85	+ 1	86
71	Perm	1887	30	1	108	37	+32	18
72	Orvinio	1872	30	17.2	105	85	−73	15
73	Mezö-Madaras	1852	Sept. 4	4.5	65	26	− 5	25
74	Agen	1814	5	0	95	75	+75	5
75	Sauguis	1868	7	14.5	105	46	+44	15
76	Limerick	1813	9	18	65	29	+11	25
77	Epinal	1822	12	19	55	45	+27	35
78	Honolulu	1825	13	22.5	74	17	− 6	16
79	Tjabé	1869	19	9	135	69	+38	45
80	Muddoor	1865	20	19	86	82	+83	4
81	Khairpur	1873	22	17	127	39	+13	37
82	Chassigny	1815	Oct. 2	20	60	40	+25	30
83	Ngawi	1883	3	—	48	50	+23	42
84	Stewart Co.	1869	5	23.8	87	130	+50	3
85	Klein-Menow	1861	7	1.5	94	12	+11	4
86	Cold Bokkeveld	1838	12	21	72	18	− 2	18

No.	Name	Year	Date	Hour	qS	qQ	q	Comp.
					°	°	°	°
87	Sarbanovac	1877	13	2	88	6	+ 7	2
88	Borkut	1852	13	3	42	48	+ 3	48
89	Carbarras Co.	1849	31	3	55	34	+ 5	35
90	Nulles	1851	Nov. 5	5.5	138	66	+31	48
91	Ensisheim	1492	16	0.5	82	10	+ 6	8
92	Gross-Liebenthal	1881	18	18.5	90	30	+30	0
93	Mauerkirchen	1768	20	4	107	20	+10	17
94	Charsonville	1810	23	1.5	141	80	+38	51
95	Blansko	1833	25	6.5	113	25	— 7	23
96	Dhulia	1878	27	6	115	26	— 5	25
97	Shalka	1850	30	4.5	90	75	−75	0
98	Allahabad	1822	30	6	96	17	−17	6
99	Bustee	1852	Dec. 2	—	91	29	+29	1
100	Tourinnes la Grosse	1863	6	23	63	30	+12	27
101	Aussun	1858	8	19.5	88	42	+43	2
102	Wold Cottage	1795	13	3.5	43	48	+11	47
103	Benares	1798	13	8	71	25	+18	19
104	Weston	1807	13	18.5	130	53	+28	40
105	Rochester	1876	21	8.8	73	16	— 1	17
106	Pegu	1857	26	14.5	105	16	— 5	15
107	Ski	1848	27	—	97	8	— 4	7
	Mean						23.7	20.6

TABLE III.

IRON METEORITES.

No.	Name	Year	Date	Hour	qS	qQ	q	Comp.
1	Nedagollah	1870	Jan. 23	—	101	46	+43	11
2	Johnson Co.	1886	Mar. 27	3	95	15	+14	5
3	Rowton	1876	Apr. 20	3.2	63	70	+56	27
4	Agram	1751	May 26	6	36	56	+10	54
5	Braunau	1847	July 13	15.8	84	19	+18	16
6	Dickson Co.	1835	Aug. 1	—	8	85	— 6	82
	Mean						24.5	32.5

In only four cases out of the 113 computed did the meteorite's absolute quit lie more than 90° from that of the Earth. About one quarter of the observations were made at night.

In Table IV the monthly means are recorded. The first column gives the month, the second the number of meteorites observed, and the third, fourth, and fifth the mean values of the angles qS, qQ, and q.

TABLE IV.

SUMMARY OF THE STONY METEORITES.

Month	No.	qS	qQ	q	Month	No.	qS	qQ	q
		°	°	°			°	°	°
Jan.	6	94	39	+17	July	8	67	40	+14
Feb.	9	98	52	+32	Aug.	8	70	45	+ 2
Mar.	5	108	36	+16	Sept.	9	90	48	+31
Apr.	6	98	47	+32	Oct.	8	68	42	+15
May	17	90	45	+ 5	Nov.	9	108	39	— 2
June	13	89	32	+19	Dec.	9	85	30	+15
							89	41	+16

The mean of the monthly quits, as is shown by the last figure in the third column fell but 1° short of being at right angles to the direction of the Sun. This quantity may be compared with

the analogous one represented in Figure 1 where it is shown that the maximum number of meteorites fell at about an hour and a half, or 22° before the Earth's quit reached the meridian, that is at 6ʰ. That result as we have seen was affected by the habits and characteristics of mankind. This is not true to the

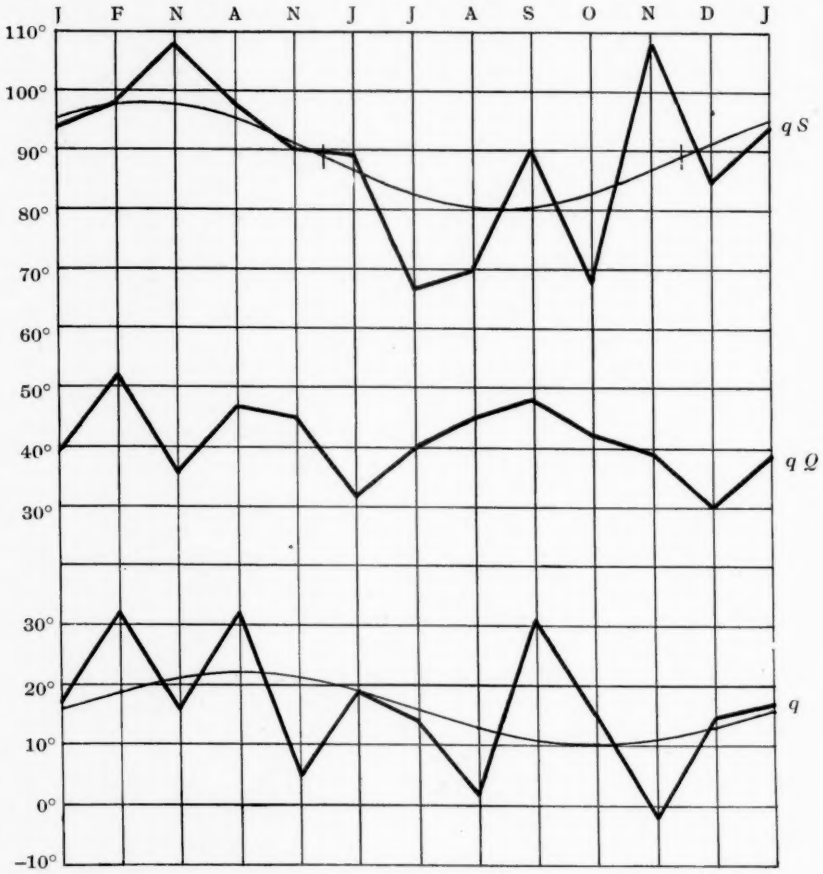

FIGURE 2.

same extent of the later result, for a meteorite falling for instance at four o'clock might very well have an angle qS of any amount less than 150°, and but one meteorite is known for which qS exceeds this figure, the second largest value being only 141°. Since more meteorites are observed to fall by day than by night, however, there would be a slight deviation produced

by this cause, which might very well amount to more than 1°. It is therefore probable that the mean value of qS is about 90°. Comparatively few quits lie far north or south of the ecliptic, so that they will not interfere materially with this conclusion.

The results given in Table IV are plotted in Figure 2, the abscissas of the observations giving the middle date of each month. The ordinates are taken from the last three columns of the table. If the meteors all followed circular orbits or if their perihelia were uniformly distributed in longitude, all the ordinates of the upper curve, representing the angle qS, would be equal. As the ordinates appear to show a systematic arrangement, we conclude that the orbits are elliptical, and the longitudes of their perihelia follow some definite law. Drawing a sinusoidal curve through the observations we find that the nodes occur about the first of June and December. The sum of the six intermediate ordinates in the first and in the last part of the year average 96° and 82°, difference 14°. The mean differences from 89° are therefore +7° and −7°.

If we construct a rectangle on the diameter of a semi-circle, the area of the rectangle being equal to that of the semi-circle, the altitude of the rectangle will be $\frac{\pi r}{4}$. Multiplying 7° by $\frac{4}{\pi}$ gives us 9° for the maximum ordinate of the sinusoid. Therefore on the first of March the mean value of the angle qS is 9° greater than the mean, and in the first of September it is 9° less. The perihelion therefore occurs about the first of June in longitude 250°.

To compute the eccentricity let us assume that the mean semi-diameter of the meteor's orbit is the same as that of the Earth. In Figure 3 let E be the center of the orbit of the Earth and M the center of the orbit of the meteorite. Then in the triangle CME we have $CM = CE = 1$ and the angle $MCE = 9°$, whence $ME = 0.157$. If S represents the Sun, then the eccentricity of the orbit of the meteorites, after allowing for that of the Earth, will be 0.14. The drawing is approximately to scale, and the dotted lines represent the largest and smallest orbits that we can intersect. It must be remembered, however, that Newton computed his absolute quits on the supposition that the meteoric orbits were parabolas. Since they prove to be ellipses of very moderate eccentricity, this would place their absolute quits much nearer the quit of the Earth, and consequently still further reduce the resulting eccentricity. The deduced value 0.14 must therefore be considered as a maximum, while the true value can

hardly be over 0.10 or about that of the planet of Mars.

Turning now to the second curve of Figure 2, representing the angle qQ, we find two distinct minima in June and December, corresponding closely to the dates when we reach the perihelion and aphelion of the meteoric orbits. On these dates we find the orbits of the Earth and the meteorites are most nearly parallel. This curve is therefore confirmatory of the upper one, although the quantities measured in the two cases are quite distinct.

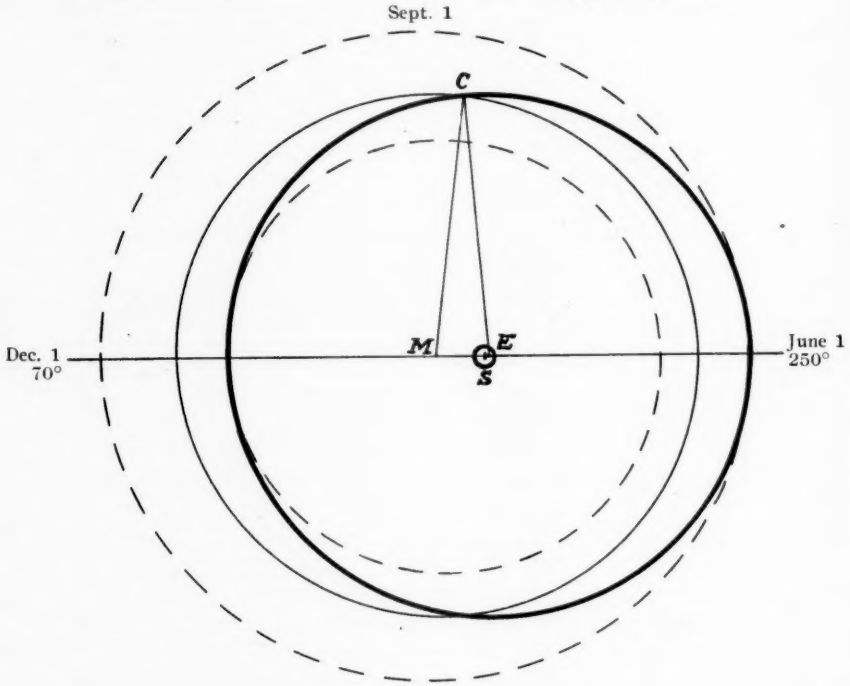

FIGURE 3.

Since most of the meteorites arrive from the vicinity of the Earth's quit, and since most of the observations are made in the northern hemisphere, we should expect to find the greatest number of meteorites,other things being equal, when the Earth's quit was highest above the horizon. According to Figure 1 the greatest number of meteorites are observed in the quadrant located about 3^h. The Earth's quit is highest in the northern hemisphere in longitude 90°. Longitude 90° is on the meridian at 3^h on May 6. We should therefore expect to find the great-

est number of meteorites early in May, and the least number early in November. By Figure 3 we find the orbits of the meteorites most concentrated in May and June, and least so in November and December. This would add to the other effect. We also notice that the difference in speed between the meteorites and the Earth would be greatest about June 1 and December 1. This would tend to create a maximum at both of these times. All three causes therefore unite to produce a large number of falls in May and June, while the last cause tends to neutralize the other two in November and December. The cause of the larger number of falls observed in May and June and the comparative uniformity during the rest of the year is therefore explained.

An examination of Figure 3 shows that during the months from March 1 to September 1 the meteorites are generally travelling faster than the Earth. They should therefore overtake it, and fall between noon and midnight, as shown in Figure 1. On the other hand between September 1 and March 1 the Earth should overtake them, and the falls should occur between midnight and noon. An examination of Table I shows that in the six months from March to August inclusive, during the first twelve hours of the day 67 falls were observed, while during the last twelve hours there were only 23, ratio 2.9. During the six months from September to February inclusive, in the first half of the day there were 49 falls, and during the last half 30, ratio 1.6. It appears therefore that near perihelion the swiftly moving meteors exceeded the slowly moving ones nearly in the ratio of three to one. Near aphelion the ratio was but little more than one half as great, thus independently confirming the form of the orbit and the position of perihelion.

The fact, as earlier noted, that four meteorites overtake the Earth to three that are overtaken by it clearly indicates that the mean semi-major diameter of their orbits must be slightly greater than unity. An inspection of Figure 3, however, will show that this excess must be very small. If all the orbits were similar to the mean orbit, differing from it only in size, and if the meteorites were uniformly spaced, then we should intersect just about four orbits outside of the mean orbit to three orbits inside of it. This simple arrangement is modified by the variations of the individual orbits among themselves. While our data are inadequate to determine the size of the semi-major axis with accuracy, yet it is seen that it can exceed unity by only a few per cent.

While many of the meteoric quits lie south of the ecliptic, it

will be noted by the last column Table IV, that most of the mean quits are positive, and the mean ot all the monthly quits is +16°. This is doubtless due to the fact that practically all of the observations were made in northern latitudes. An examination of the lower curve of Figure 2 shows that the results lie along a sinusoid of small amplitude, whose ascending node occurs about the middle of January or in longitude 115°. The mean of the ordinates of the observations during the five months February to June inclusive is +21°, and during the five months August to December +12°. Using the same method as that employed in dealing with the upper curve, we find the maximum ordinate of the sinusoid must be 6° which gives the inclination of the mean orbit to the plane of the ecliptic.

The elements of the mean orbit of the stony meteorites are therefore as follows:—

$$a = 1,\ \pi = 250°,\ \Omega = 115°,\ i = 6°,\ e = 0.14 -$$

Although the inclination and eccentricity of the mean orbit are small, yet the mean inclination and mean eccentricity of the orbits classed as a group are both fairly large. The arithmetical means of all the inclinations are given at the bottom of the eighth columns of Table II and III, and are 23°.7 and 24°.5 respectively. The arithmetical means of the complements of the angle qS are given at the bottom of the last column of the same tables, and are 20°.6 and 32°.5. By a similar construction to Figure 3 we find for the mean eccentricity of the orbits of the stony meteorites 0.36, and for the orbits of the iron meteorites 0.56. The least eccentricity of any known cometary orbit, that of Holmes, is 0.41, the mean for the comets of Jupiter's family 0.64. It is therefore clear that the iron meteorites follow cometary orbits, while the eccentricities of the orbits of the stony meteorites are appreciably smaller. While this simple method of determining the eccentricity is fairly accurate for orbits whose eccentricity is small, and which are therefore nearly circular in shape, it is, of course, less accurate when the ellipticity of the orbit becomes more pronounced.

A few words may now be said on the origin of meteorites in the light ot the facts here set forth. Owing to their frequently conglomerate structure, the geologists are agreed that they are only the fragments of a once much larger body. On the planetesimal hypothesis Professor Chamberlin explained their origin as being due to the fracture of one or more asteroids by the near approach of another Sun, *Astrophysical Journal* 1901, **14**, 17. This we now see cannot be true, as their aphelia should

in that case reach out as far as the zone of the asteroids, which in the great majority of cases certainly is not the fact. In POPULAR ASTRONOMY 1909, **17**, 273, it was shown that the only other reasonable hypothesis hitherto suggested was that the stony meteorites took their origin when our Earth was fractured at the time of the birth of the Moon. It now appears that the Earth and Moon are the only two large bodies whose orbits are intersected by the orbits of the stony meteorites, and the existence of these meteorites therefore now furnishes an additional argument in favor of this former cataclysm.

In this, and in my previous papers on this subject, it has been convenient to separate the iron from the stony meteorites, and to assume that all the former were associated with comets, and all the latter with the Earth. There is, however, a third and very small class of meteorites, generally recognized, in which although some stone exists, the proportion of iron to stone is much larger than is usually found to be the case, and the question may be raised to which class do these orbits properly belong.

Only one of this class of meteorites is found in Professor Newton's list. This one fell at Estherville, 1879 May 10 at 5^h. For it we have $qS = 50°$, $qQ = 40°$, $q = -2°$, and complement $qS = 40°$. The value of the complement of qS is rather large, but otherwise its orbit exhibits no marked peculiarity to differentiate it from the other stony meteorites. Two of the stony meteorites referred to early in this paper were apparently moving with high velocity.

Knyahinya	1866 June 9, 5^h,	$qS = 85°$,	$qQ = 32°$,	$q = +38°$
Amana	1875 Feb. 12, $10^h.2$,	$qS = 104°$,	$qQ = 26°$,	$q = -21°$.

The high inclination of the quit of the former to the ecliptic, and the apparent high speed of both, as already described, involving a remote aphelion, might imply cometary orbits. On the other hand for the iron meteorite which fell at Braunau, 1847 July 13, $15^h.45$ we find $qS = 84°$, $qQ = 19°$, and $q = +18°$. These figures taken in connection with the hour of fall indicate a velocity less than that of the Earth, and therefore a smaller value of the semi-major diameter.

Observations of falling meteorites made without warning, by untrained observers, are necessarily liable to grave errors. While the means of many observations may be trusted, contradictory individual observations must be accepted with extreme caution. As above mentioned, those stony meteorites that overtook the Earth were 1.33 times as numerous as the more slowly moving ones which were overtaken by it. On the

other hand by the third paragraph of this article we find that the more swiftly moving iron meteorites outnumbered the others as much as 5 to 1. That is to say but one fell in the morning hours, and was overtaken by the Earth, while five fell between 3^h and 9^h. It is therefore clear that most stony meteorites move with terrestrial velocities, and most iron meteorites much faster. Whether any of the stony meteorites move with cometary velocities is perhaps doubtful. That one iron meteorite was moving with a terrestrial velocity appears plausible.

As distinguished from the stony meteorites, the great majority of falling stars are certainly associated with comets, and in closing we may refer to an explanation often given in the text books of the fact that twice as many of them are met in the early morning hours as are encountered in the evening. As stated by Young in his General Astronomy § 772 "In the evening we only see such meteors as overtake us; in the morning we see all that we either meet or overtake." Now if most of these meteors or falling stars, are moving with cometary velocities, this explanation is certainly incorrect, for the simple reason that, saving for exceptional circumstances, we cannot overtake any of them, since they are all moving faster than the Earth.

The true reason that we meet more is the same that when walking, we meet for instance, more electric cars than overtake us. If the cometary speed is 1.4 times that of the Earth, then the theoretical ratio of the number of meteors that we meet to those that we overtake will be $\frac{1.4 + 1.0}{1.4 - 1.0} = 6$. This supposes that there are the same number of meteors going in both directions. Since many of these meteors are related to the comets of Jupiter's family, the majority of them must have a direct motion. Since the observed ratio is only 2, this shows that in the region of the Earth's orbit there are three meteors possessing a direct motion to one whose motion is retrograde.

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PLANET ORBITS IV.

THOMAS CURRAN RYAN

FOR POPULAR ASTRONOMY.

Velocity.

Speed and velocity do not necessarily mean the same thing as those terms are used in physics. The former denotes only the time rate of motion while the latter combines the ideas of speed and *direction*. By this discrimination we are enabled to signify the result of two speed impulses exerted upon the same ponderous body but along different lines. Such a combination

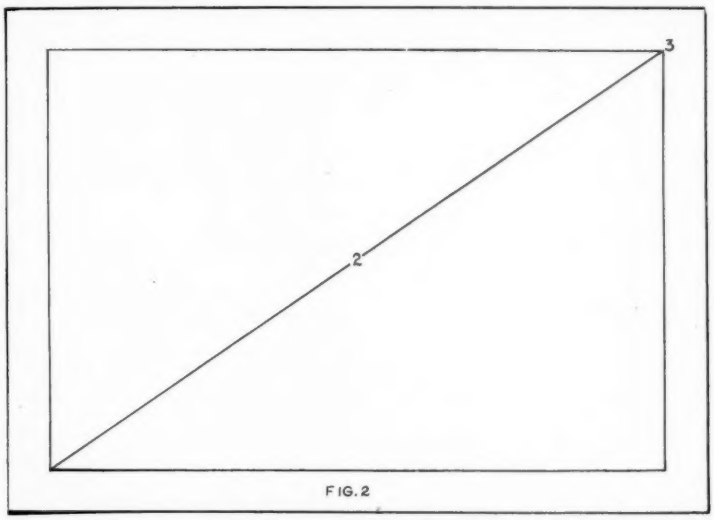


FIG. 2

never gives an aggregate equal in magnitude to the sum of the imparted speeds. What the resulting *velocity* will be is ascertainable from the law of the parallelogram of velocities. This law, in its simplest manifestation, is illustrated by Figure 2 of preceding articles of this series, which figure is here reproduced, and, as before fully explained, it represents the flattened out surface of a cylinder of space large enough to contain one year's journey of the Earth and Sun. The planet has a vertical impulse of speed sufficient to move it across the diagram—396,000,000 miles, in one year; it has a lateral impulse that would carry it across in that direction, 584,000,000 miles in the same time. Having these two impulses it cannot obey either of them but

must move in a compromise direction along the diagonal line, and with a compromise speed,—in other words with a new velocity derived from the others, and which, although it moves the Earth 396,000,000 miles in one plane and 584,000,000 miles in another, perpendicular thereto—a total of 980,000,000 miles —only carries it 703,000,000 miles from the starting point. In this process the two imparted velocities of 12.5 and 18.5 miles per second, 31 in all, are combined into one of 22.3.

If these two speed impulses had been upon the same line and in the same direction, they would be added together and the result would be a velocity of 31 miles per second. Being upon diverging lines they are opposed, in a degree proportionate to their divergence; hence they retard each other.

As manifested in the helicoidal orbit, neither of the two impulses of simple motion above referred to is centripetal in tendency, although the planet's entire aggregate *velocity* is derived from them. Neither of them is exerted upon a direct line between the Earth and Sun; hence neither of them tends to move the Earth toward the Sun. Indeed, we should not be justified in asserting, dogmatically, that the actual helicoidal velocity of 22.3 miles per second is derived from two speed impulses of 18.5 and 12.5 miles, retangular to each other. According to Laplace's theory, and modern variations of it, the Earth's velocity was thus derived. Upon theories of *capture* by the Sun the original velocity would be simple,—the result of a single speed impulse of 22.3 miles per second which happened to be in the right diagonal direction. Upon another theory which has recently gained some vogue among philosophers,—that there is a supervising Intelligence manifested in "directivity", the problem becomes one of telekinetic power and engineering skill possessed by the Architect of the Universe. With these questions I am not dealing now. The velocity was caused somehow, since it exists. Its power as a contributory cause of other phenomena is the same whether its own cause may have been one thing or another. Also, its character as the motion of a single body in a single direction is as true if derived from two impulses as if derived from one. The Earth possesses only one translatory or molar motion, since nothing can simultaneously occupy different places in space. Two or more speed impulses can impart only one motion. Consequently the Earth does not possess a motion that carries it in its relative orbit around the Sun at a speed of 18.5 miles per second, and another which carries it toward the solar apex with the same speed at which the Sun

travels. On the contrary, the Earth has but one line of motion, —one velocity, which enables it to accomplish both of these results by going "cross lots."

But another impulse of motion, namely, attraction, enters into the formation of the orbit, and this element is centripetal. It is, however, represented as being very weak compared with the other, since we are told that, at the distance of 93,000,000 miles, it is only able to exert a pull sufficient if unopposed, to draw the Earth toward the Sun at the rate of one-ninth of an inch in a second of time, or, without acceleration, about fifty-five miles in a year. If we assume this to be true, and make a comparison, we find that the force which moves the Earth 22.3 miles per second in its helicoidal orbit, is about thirteen million times as strong as attraction. This centripetal force, however, weak it may be in comparison with the other, has nevertheless an important function in forming the orbit. Being exerted upon a direct line from Earth to Sun, it quite obviously cannot assist in the apex-ward flight of the planet,—in other words it cannot add to the planet's aggregate velocity, though it does prevent that velocity from being uniform, constantly causing slight alterations in its direction, retarding it during one half of the year and accelerating it the remaining half year. Its *usefulness* is wholly manifested in *curving* the straight line of the Earth's simple motion, thus altering rectilinear into curvilinear motion. As has been explained in former articles of this series, this curvilinear result arising from attraction can be made to appear graphically if we change Figure 2 into a cylinder by joining its ends, leaving the diagonal line outside, which thus becomes a spiral.

Let us now look more closely into this process whereby the straight line of motion is changed to a spiral. It will be obvious that any impulse of simple motion, or motion in a straight line, which cannot possibly produce a spiral orbit, must result either in coalescence with, or escape from, the Sun. Obviously, too, there are many such straight lines from which a spiral orbit could not possibly result. Also, it is clear that, with the Earth's present speed impulse, rectilinear motion directly towards any point upon the Sun's path not yet reached by the Sun could not be curved into a spiral orbit around that path. Neither could the Sun with an attractive power only able to move the Earth one-ninth of an inch per second *hold* the Earth, or "drag" it along as some writers assert. If the Earth had no motion except such as is imparted by attraction, the speed of twelve and

one-half miles per second possessed by the Sun would constantly carry it farther and farther away from a planet moving only one-ninth of an inch per second. On the other hand, conditions from which a spiral orbit could be evolved might result in three forms of orbit, *i. e.*,—first, one such as the Earth now has, namely, a spiral that moves around a cylinder of space having surface elements parallel to the Sun's path; second, one that moves around a conical cylinder whose diameter enlarges constantly; third, one that moves around a conical cylinder whose diameter decreases constantly. In the first of these cases, the orbit would be permanent; in the second, the Earth would recede farther and farther from the Sun; in the third, the Earth's spiral would wind itself into the Sun, sooner or later.

What conditions are needed to produce the first of these orbits,—the permanent spiral?

All impulses of motion simultaneously imparted to a ponder-

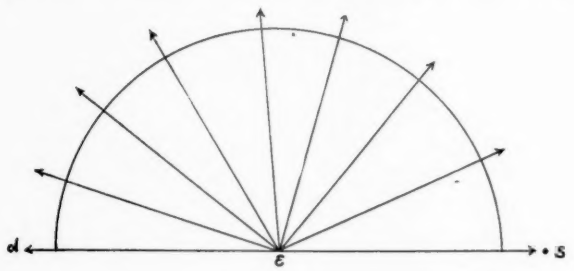


FIG. VIII

ous body along diverging lines, oppose and retard each other according to the law of the parallelogram of velocities. The pull or stress of attraction upon the Earth must therefore be resisted strongly by the planet's independent motion. This is illustrated by Figure VIII. Let us suppose the Earth (*e*) to be attracted by the Sun (*s*) and to be endowed with motion along the line of attraction—*e-s*, and in a direction opposite to *s*, or toward *d*. This condition would produce the maximum of opposition between the two forces; the resultant direction would be that of the stronger force and the conserved speed would be the difference between the two. Now let us imagine that the line of attraction from Sun to Earth is the diameter of a circle, as shown in Figure VIII. Divide the semi-circle into sectors as many as may serve for illustration. Now change the direction of the Earth's motion to the radii bounding these sectors in the

figure. All these changes will, in varying degrees, reduce the amount of opposition between the forces below what it is when they are *directly* opposed. Yet they will not cease to oppose and retard each other in some degree until they exactly coincide; and the proof of this is that until then the resultant from combining the two velocities will be less than the sum of the two speed impulses.

As attraction deflects the Earth's motion from what would otherwise be a rectilinear path, the straight line upon which the Earth would otherwise move must be one which would constantly carry the planet farther away from the Sun. This is proved by the fact that notwithstanding this slight motion of the Earth sun-ward, its mean distance from the Sun remains the same year after year, so that the rate at which the Sun attracts the Earth just equals the rate at which the planet would recede from the Sun if unattracted. In other words, on account of the Earth's *direction* of motion being just what it is, attraction is able to hold the planet at a certain mean distance; the Earth's motion, though it *tends* to increase that distance, is unable to do so: attraction, though tending to draw the Earth toward the Sun cannot lessen the mean distance between them. When the Earth is *behind* the Sun, as explained in the third chapter of this series attraction aids in the apex-ward flight of the planet,—that is to say, the Earth's simple motion is reinforced by attraction; the line of motion draws nearer to the line of attraction and consequently becomes more straight: that is, less curved. Therefore, the force of attraction is never *wholly* centripetal except at the moments when the Earth is even with the Sun in the apex-ward journey, namely, at the aphelion and perihelion moments. At all other times attraction is partly expended either in accelerating or retarding the Earth's motion; only the portion not thus used manifests itself in changing the distance. At perihelion the Earth has overtaken the Sun and the centripetal force is at its greatest; but a safety valve has been provided for it by the increased speed of the Earth and the decrease in curvature of its line of motion, causing the largest angle between attraction and the Earth's motion. These obstacles to attraction are at once reinforced by another as the Earth passes the Sun, apex-ward. Here the work of attraction, lately expended in accelerating the planet's motion, is now expended in retarding it. Thus, the two forces are in a "deadlock,"—just balanced, each able to offset the other, neither strong enough to overcome its opponent.

Obviously, then, the *direction* of the Earth's impulse in its helicoidal orbit is one that if unaffected by attraction would constantly increase the distance between the Earth and Sun. Obviously, also, if the centripetal force is as weak as represented, the centrifugal impulse is equally weak. If we find the exact strength of this centrifugal impulse, we shall have gone only part of the way toward discovering the exact line of its direction. We shall only have the plane in which that line lies. We shall not have its angular relation to the line of the Sun's motion. Moreover, the greater portion of the plane found must be rejected as impossible. This will be illustrated by Figure 9.

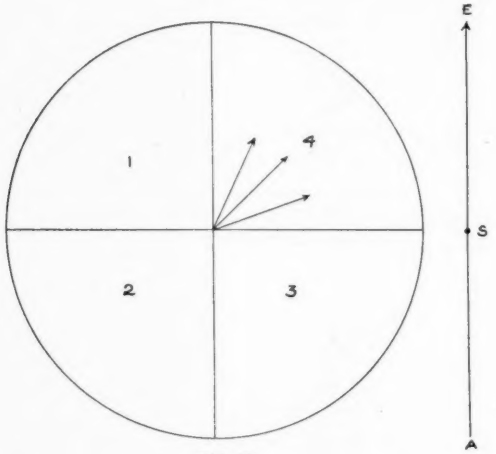


FIG. 9

We are to imagine a planet at the center of the circle, and the Sun (*S*) at a point upon its path. The line of the Sun's path,—*A-E*, is not in the plane of the circle, but lies farther away from the reader—at the needed distance, whatever that may be. There will be an angle between them sufficient to allow the planet its centrifugal struggle against attraction. Granted that all these conditions are what they should be, the remaining problem is the *direction* in which the planet shall be propelled, at its present speed, through the field enclosed by the circle in Figure 9. Obviously, choice is to have a meaning here, as to promise of results. Unless we allow ourselves to be superstitious as to what attraction can accomplish; unless we believe it can perform miracles, or adjust itself to varying conditions and make an orbit at all times when one is needed for a planet,

we will instantly dismiss as impossible all lines of motion through sector 2 of the circle. We will have no hope of the required results from most of those in sector 3, and we will question all of them. Some of those in sector 1 will be dismissed at once, and the others will be seriously doubted. We shall not feel ourselves upon safe ground until we enter sector 4, and when we choose a line of direction there we must consider the planet's own speed, its distance from the Sun, and its mass, and make the direction agree with these other forces and conditions. A few lines of motion in this sector 4 are indicated by arrows. As these incline toward the Sun's path, *A-E*, the planet's speed must be increased and its distance lessened, so that the coils of its spiral shall be folded closer together, and a single revolution shall not carry it too far towards the solar apex. As the directions of the planet's motion incline away from the Sun's path, the coils of its spiral are thereby lengthened so that it requires less speed and may have greater distance. Evidently, if it had the swift speed needed for the closely coiled spiral, it would move apex-ward too rapidly. Diagrams illustrating the angles and distances, for the several planets, as related to the direction of the Sun's path, are shown in the

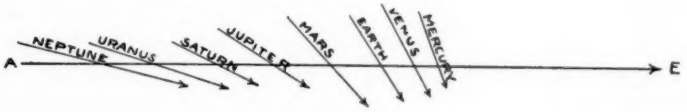


FIG. X

first chapter of this series, but I append, here, Figure X, which facilitates comparison of the angles but shows nothing as to distance from the Sun. This diagram, like its predecessors in Chapter I, shows what the angles would be if the relative orbits were perfect circles; but as the eccentricity is not large in any case, these angles will approximate closely enough for the illustration I am attempting to make.

The line *A-E* in Figure X indicates the Sun's path, motion from left to right. The arrows crossing it show one element in the directions of each planet's impulse of simple motion. Of course these directions do not actually *cross*, or *touch* the Sun's path, as they *appear* to do in the figure. They are all directed toward different lines in space, above,—that is to say, nearer to the reader's eye than the line *A-E*. How far above, the diagram does not attempt to show, nor do I know these angles. But they are so closely related to those shown in the figure

that they must also grow more and more obtuse (as related to the plane of the paper page), with decreasing distance from the Sun. Their *apparent* manifestation in the relative orbits, is not here referred to. That is *alike* for all the planets—*apparently* a tangent in the plane of the relative orbit; but in order that it can assume such an appearance in the relative orbit, the actual direction must vary for the several planets according to mass, distance and speed. I need hardly say that by "the actual direction" I mean what it would appear to be if the same curvilinear motion could and did exist without any Sun, or other means of causing the illusory appearance of a closed orbit.

I append a tabular statement of the speed impulses of the several major planets, and showing some effects of combining them in the spiral orbits:—

Speed Impulses, Miles per second	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Rectilinear	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
Curvilinear	29.00	21.90	18.50	15.00	8.10	6.00	4.20	3.40
Total	41.50	34.40	31.00	27.50	20.60	18.50	16.70	15.90
Per cent rectilinear	30.00	36.50	40.00	45.00	60.70	67.57	74.80	78.60
Per cent curvilinear	70.00	63.50	60.00	55.00	39.30	32.43	25.20	21.40
Helicoidal speed	32.20	25.20	22.30	19.54	15.00	14.00	13.20	12.90
Amount lost	9.30	9.20	8.70	7.96	5.60	4.50	3·50	3.00
Per cent lost	22.40	26.74	28.00	29.00	27.20	24.30	21.00	18.87
Per cent saved	77.60	73.26	72.00	71.00	72.80	75.70	79.00	81.13

The foregoing table may be understood better with a few words of explanation :

By "rectilinear" impulse is meant that which carries the planets apex-ward, with the Sun.

"Curvilinear" refers to simple motion in the plane of a planet's relative orbit, and curved by the Sun's attraction.

"Helicoidal" refers to the compromise velocity derived from the two impulses of simple motion. It stands for the speed *saved* from the total, as the figures in the line following it do for the speed lost through opposition. The per cent lost and saved, from the total, is shown in the last two lines.

Wausau, Wisconsin.

(Conclusion).

THE EVENT OF 1984.

N. W. MUMFORD.

FOR POPULAR ASTRONOMY.

On November 29, 1982, in a room overlooking the Boulevard des Italiennes, there was held a notable meeting of some of the world's most distinguished scientists. The gathering had been planned for over a year, for a specific purpose, and constituted the Planetary Committee of the International Societyof Astronomers. The membership of the Society for that year numbered one hundred, and the list was full. Of these, ten members made up the Planetary Committee. The nine who met on the 29th, of November bore names familiar the world over wherever pure science was taught or popular interest in matters extra-mundane aroused. The aged Marquis Takahito was absent, and the Committee was informed by ærogram that advancing years must henceforward confine the distinguished Japanese to his home in Nagasaki.

Shortly after noon the Chairman, Sir Gilbert Spencer of Melbourne, called the meeting to order, for the purpose of hearing the report of the Sub-committee on Communication. There where present, Spencer, famous for his researches on Nova Carinæ, the brilliant outburst of 1969, which all who lived in the southern hemisphere can remember, when the Galaxy was adorned for more than a week with a new star that outshone Canopus; Dr. Gould, of Auckland, who by the introduction of new methods in sidereal photography, discovered the true relation of the Magellanic Clouds to the Galaxy; Otis Clarke, of Cambridgeport, astronomer and grinder of the world's greatest lenses, the head of an old and famous house; Jules Lescaubault, of the Paris Observatory, who had never in his life looked through a great telescope, but whose mathematical genius interpreted the researches of others with a precision that must rank him with his famous predecessors, Laplace, Adams, Leverrier and Newcomb; Alice Clerke Lovering, of Greenwich, the scientific historian, herself the Committee of one on the Progress of Astronomy; Baron Schoenbrun, of Heidelberg, builder of the great ten foot reflectors, inventor of mercuroid, that solidifies a revolving basin of mercury to a hardness and tensile strength superior to the best steel; Stanovitch, of Pulkova, who with the camera attached to one of

Schoenbrun's reflectors, and with the help of Lescaubault's demonstration, discovered the ninth major planet, Oceanus, that moves in its orbit through only 58′ of arc in the terrestrial year, and reflects sunlight too faintly for detection by the unaided telescope; Dr. Bannard, of Mount Hamilton, probably the most tireless observer since the days of Sir William Herschel, and Director of the world's best equipped observatory; and finally Rhodes Raines, of Gondar in Abyssinia, a new station at an elevation of about seven thousand feet, in the hands of a spectroscopic genius that had already made it famous.

These members together with their associates in the International Society of Astronomers, enjoyed singular privileges, and exercised an influence unknown to the generations preceding them, but recognized in our day as proper and just. Indeed the influence of the vast Society of Scholars, as we recognize it, was almost unfelt a century ago. Our time-honored device, "The Truth Shall Make You Free" was not a guiding motive of thought and action to the individual in those days, nor the arbiter between nations, nor the test for success or failure in the great social movements of the time. Among our immediate ancestors, each country and each individual seems to have been more eager to prove its or his point of contention, than to ascertain the truth.

At this session of the Planetary Committee, the Chairman announced the gift of funds amounting to the five hundred thousand pounds sterling from the Rothschildbund, deposited with their treasurer, especially to further the work of the Subcommittee on Communication. Messrs. Gould, Stanovitch and Bannard then presented their report: To the Planetary Committee of the International Society of Astronomers, Mr. Chairman and members: The general results of our special work are already well known to you, and in fact to all who are interested, through the various publications that have been issued from time to time, during a rather prolonged investigation.

On May 20, 1984, or about seventeen months from now, the planet Mars, in the constellation Scorpio, will occupy the position in its orbit that we recognize as the most direct opposition possible, and may term a true, or ecliptic opposition, and the first one of its kind for seventy-nine years. The approach will not be the nearest possible by somewhat over twenty million kilometers, a fact that need not disturb us. Most happily we may say, the ascending node of the superior planet coincides with the precise moment of opposition; our Earth in inferior

conjunction, will occupy a position in direct line with the Sun as seen from Mars, and will appear upon the limb at 4 hours 8 minutes Greenwich Mean Time. The transit will be nearly equatorial, and will last 7 hours 54 minutes.

We are met here to-day to discuss the steps that your committee proposes to take on the occasion of this transit. If it shall be possible to transmit an intelligible signal across the seventy-seven million kilometers of intervening space, we wish to leave no means untried of accomplishing such a result. We work on the assumption that intelligence on Mars, if such exist, will be in a receptive mood, and that the Martian observers will be keenly alive to the singular astronomical event that will then be taking place. We have the possibility in store for us that our labors may not be in vain, and that an answering sign may appear on the bright face of the planet, to reward the observers at the great instruments here, and possibly to impress the photographic plate.

You are all aware that at the time of the transit, the Earth will present a south-temperate exposure, and that the center of our disk, viewed from Mars, will correspond with about the sixty-second meridian west on the geographic scale. Your Committee proposes, as the site of the experiments, the city of Villa Nueva, Argentina. The area of the province of Cordova, of which Villa Nueva is the principal town is over 70,000 square miles, or more than twice the area of Ireland. One of our members has visited the locality, and we have the assurance of the people of influence of that section, that they will do all in their power to further our efforts. The method of course, will be an electrical display with mirrors. We present as a separate exhibit, the plans and specifications for about two hundred and seventy linear miles of lighting. The breadth of each figure or part thereof will not be less than one and one half miles. The power will be derived partly from the Rio Saladillo, partly from the Tercero, and partly from helio-electric batteries. We intend to install one million arc lights. The cost of this entire undertaking will not be more than eight hundred and forty thousand pounds. We are enabled to report this moderate expense, because of the cheapness of the sources of electric power. Allow us here to remind the skeptical, who are familiar with the reports of the Sun's effulgence during transits of Venus, that probably no such overpowering brilliance will disturb whatever observers there may be upon Mars, on account of that planet's great distance from the Sun as compared with the Earth's.

It remained for your Committee to consider the exact figure or shape that the display shall take. This point has been the subject of considerable discussion. The form of a cross has been suggested, two broad straight lines crossing each other at right angles; also the figure of a telescope upon a tripod, the figure of a five pointed star, the figures of various animals, and the outline of the continent of South America. Your Committee has decided upon the figure of an oval, whose longest diameter shall be ninety miles, and the shortest sixty. In the center of the oval and upon its longest diameter, shall be a broad track of light extending for twenty miles. On each side of this track, at the upper end say, shall be located two round fields of light, equidistant from each other and from the sides of the oval. Each of these fields shall be five miles in diameter. Separated from the lower end of the central track by a blank seven miles wide, and running seven miles and a half on each side of the oval's longest diameter, shall be a second track at right angles to the first. In all there will be four figures inside the oval. You will note that it is intended to display the features and the outline of the human face.

Finally your Committee begs your leave and coöperation in proceeding promptly with this design, and submits herewith exhibits of estimates, together with drawings. Among the latter is an interesting hypothetical photograph of the display proposed, as seen through a four foot refractor at a distance of seventy-seven million kilometers. The report of the electrical engineers is also attached. Respectfully,

Gould.
Stanovitch.
Bannard.

All the members present made a thorough examination of the documents submitted. Upon motion by the Chairman, the Planetary Committee unanimously approved the plan presented by the Committee on Communication, and the scene of the latter's labors was transferred to the plains of Argentina.

Any visitor to that part of the Argentine may see the huge power houses, the long array of dynamos, and the fields of helio-electric generators, which were originally erected for one purpose, though now turned to various agricultural and commercial uses. The helio generators are of the Cove type, which we now regard as somewhat antiquated. Their combined power supplied about one third of the current required for the million lamps. Water power from the Saladillo and Tercero

furnished the remainder of the energy, which amounted in all to one hundred and fifty thousand horse power. The lamps used were of the one hundred and forty volts carbon flare type, four times more luminous than the old style arcs. They were mounted in series with search-light backing. The switch control admitted an interruption of the current, so that intervals of darkness could be made to contrast with the great blaze.

The contract for erection and installation was awarded to the Niagara-Victoria Company, and the work was completed and turned over to the Committee on Communication within fourteen months. Those who visited the spot and observed the night display from their planes or dirigibles, at an elevation of from one to two miles, may remember that the glare was far too intense to be endured by the naked eye.

On the 19th of May, 1984, five members of the Planetary Committee met at the famous Observatory which derives its name from the province in Argentina. Sir Gilbert Spencer, Dr. Gould, Clarke, Raines and Miss Lovering were present. What actually occurred may best be retold from Clarke's Journal.

"There was little to do during the early evening but to pray for 'good seeing'. The reports brought us were most encouraging, for there had been no excessive heat during the day, and the night was dead calm. We all felt that by midnight we would know whether or not there was to be any evident reward for our labors, or any justification for the expenditure of nearly five million dollars. Communication with Villa Nueva was frequent and easy, and we were advised beyond a shadow of doubt of the absolute preparedness of the engineers and of their apparatus. The sky above them also was cloudless. As the time drew near we assembled under the great dome, which adjoins the library. The strain of anticipation was telling on each one of us, and for the most part we walked back and forth, attempting conversation as if we were thinking of nothing worth while. We smoked hard, until Sir Gilbert, who was quietly seated, reminded us of the possibility of obscuring the objective. Imagination removed one and all to a point far from the scene around us. Whatever Martians there might be, knew, they must know, of the imminent event. Since the beginnings of things, their astronomers had had an immense inherent advantage over ours; there was no Martian atmosphere dense enough to intercept or fog their observations.

The Earth utterly invisible to them now, lost in the radiance of the Sun, unless the rare phenomenon was present, of visibility

against the solar corona, was swinging steadily in its orbit, at eighteen miles per second, rapidly covering the interval of separation from the Sun's limb.

The silent watchers on Mars were at that very moment waiting, as we waited, with all the mingled feelings that influenced us. As midnight approached the moment of contact drew near. A dim light only showed our little group gathered around the giant refractor. Miss Lovering in the observer's seat bent over the eye-piece; the silence made me think of the verse in Revelations. Now our Earth touched the Sun's limb, now half its disk impinged and the halo of refracted sunlight must have spread around the outer edge. Now the entire black disk showed, already the black drop was forming; it stretched and disappeared. Two long electric signals told that the great display on the Cordova plains was on; while we gathered still closer about the chair.

Miss Lovering's right hand grasped the eye-piece, while her left rested on the arm of the chair. 'Such a perfect night' she murmured, 'all there, from Indus to Fons Immortalis,' referring to objects on the surface of Mars. Then silence; then her low cry, 'Oh look, look, the black spot, Oh Rhodes, it's growing, Oh I can't,' and fell back in the chair. 'With your permission, gentlemen' said Raines, and bent over the instrument. I never saw better self-control. 'Where, Alice?' said he quietly. 'Close to Ulysses, a little to the east' she replied. 'I believe the spot has never been seen before' said Raines. 'It seems to lengthen; its length is certainly measurable; it's like a river of ink; its direction is changing; there is an arm extending downward, toward the north, at about a 60° angle; it's turning again at the same angle to join the first line. Good Lord, a triangle, equilateral; look again, Alice,' and Rhodes broke away from us, tottering. He told me later, that for the succeeding few moments he was quite blind. But Miss Lovering begged us to lose no time, saying that she had seen enough. My turn at the glass came quickly, and I saw the object precisely as Raines had described it. There was no longer motion in it, but there plain before us all lay the simple geometrical figure, that had never before been seen on Mars, nor anywhere else in heaven above. We roughly calculated the sides of the triangle at 160 kilometers; thus it somewhat exceeded in extent our own display. We five watched this strange spot for nearly five hours, without intermission, during which time there seemed to be absolutely no change in its appearance, until it finally faded

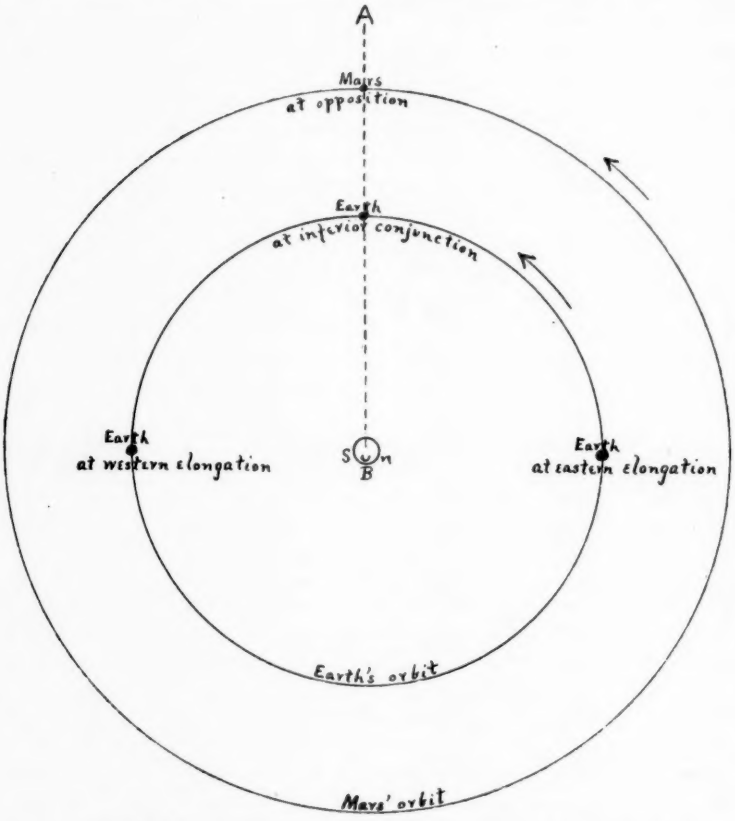
out, and was swept from view, over the planet's eastern edge. Sunrise in our southern latitude came nearly two hours later. The electric signals every half hour kept us informed of the winking lights of our display, but the dark sign on Mars sent no reply."

The civilized world was thrilled by the news. The papers were full of interviews, scientific and otherwise, and for days all issues printed charts of the neighboring planet. There was laid open a field of boundless speculation, of all kinds, some rational and much merely fantastic. It was the discovery of a new world. Science triumphant was appealed to that no efforts might be relaxed in following up the first success. The observatories were flooded with telegrams, and great sums of money were placed at the disposal of the International Society.

Fortunately for us of the present day, the reports of the witnesses of events of that night are so generally unanimous and identical, that no just doubt can be thrown on the occurrence. Further testimony is added by the photographs taken. The plate exposed in the reflector at Arequipa gave the best results, and science has agreed that the existence of that plate alone would prove the reality of the mysterious triangle upon Mars, were other evidence lacking.

The flood of controversy that has ensued, is of course fresh in the minds of all of us. The next night and for many returning nights, and for several favorable oppositions, the sign has been looked for in vain. There seems to be a pretty general agreement that our own signal was observed, hence the reason for the non-reappearance of the Martian sign is the more puzzling. Monsieur Lescaubault's explanation is simple, and is perhaps the true one. "The Martians," he argues, "have no doubt for centuries, perhaps for thousands of years, been attempting to establish communication with the Earth. On the one occasion in modern times when their efforts seem to have met with a response, it was upon the occasion of a transit. The Earth when nearest to Mars, and in inferior conjunction, is a most difficult object, we infer, or quite invisible, unless it actually crosses the face of the Sun, while their planet is most favorably situated for our observation. At such times since we assume that it is impossible for them to see any answering display, the Martians have long since given over their efforts to communicate, waiting perhaps with Martian patience, for another transit. Our own efforts should be devoted to a proper display of signals when the Earth is in the part of her

orbit leaving greatest elongation, from the Martian viewpoint, showing to them the crescent phase, and approaching inferior conjunction; or else when some distance past the latter point and approaching greatest western elongation. Possibly at the times of our elongation, the Martians have renewed their signal, but distance has prevented any detection on our part."



Line A-B shows position of Sun, Earth and Mars in May 1984, at time of Earth's transit as seen from Mars.

As our readers are aware, the Planetary Committee are about to renew their efforts to establish communication, somewhat along the lines suggested by M. Lescaubault. Their plans are drawn up on a very extensive scale. It is proposed to display

the entire Roman alphabet, one letter at a time, upon the occasion of each successive favorable position. Thereafter displays will be made of certain signs with appropriate letters attached, as △ TRIANGLE, + CROSS etc, until the entire alphabet has been used to label certain symbols. In astronomical, as in geological matters, our conception of time is of small account. The modern vast development of electrical control seems to render such a project not chimerical. The very ambitious program has powerful financial backing and we may all hope that the doubts and disappointments accumulated during the last dozen years, may before long be dispelled.

106 Wall Street,
New York.

THE OCCULTATION OF τ TAURI, (HOUGH 642).

ERIC DOOLITTLE

FOR POPULAR ASTRONOMY.

This most interesting star was discovered to be a very close and unequal double by Professor G. W. Hough on October 21, 1899. On this date while observing an emersion of the star from occultation he saw it reappear first as a star of the 9th magnitude and then, rather more than a second later, flash out in full brightness. The Moon was three days past the full so that the emergence was at the dark limb. From this observation he confidently asserted that τ Tauri was attended by a minute companion whose distance from the primary was probably not less than 0″.15 nor more than 0″.4.

I have examined this star many times on nearly perfect nights during the past seven years, but without detecting any trace of duplicity. As τ Tauri is of the 4.3 magnitude, the great inequality in brightness may render its observation in the ordinary way impossible with any existing telescope; it should certainly be examined, however, with those of the largest apertures.

The evening of March 16, (1910), has been looked forward to for many months, as on this date an occultation of the star was to occur. This was observed with the 18-inch equatorial of the Flower Observatory, a power of 223 being employed. The disappearance at the dark limb of the moon was perfectly instantaneous. As the time for emersion approached the micrometer wire was set tangent to the bright limb at the computed

point of emergence and this point attentively watched. Suddenly, a perfectly definite little point of rather bluish light appeared on the limb, which at once attracted my attention, and after an interval of approximately 0.8 seconds τ Tauri flashed out at this exact point. I am perfectly certain that this little point of light is the companion seen by Hough eleven years ago. I think there can be no doubt of this, for it did not appear exactly at the computed point of tangency but at about one degree in position angle away; it was exactly at this point that τ Tauri emerged.

The interval of time which elapsed between the appearance of the companion and that of the primary was estimated by counting the beats of a half second chronometer. This could not have been less than 0.5 seconds nor do I think that it was more than 1.0 seconds, for I believe that the companion was seen immediately upon its appearance. The estimated time was 0.8 seconds. It is probable that the companion is somewhat brighter than the 9.0 magnitutude.

The position of τ Tauri for 1880. is

R. A.	4 hrs	36 min.	2 secs.
Decl.		+22°	44′

It has a distant 7 magnitude companion measured by South in 1824. From three spectrograms taken by Frost and Adams in 1903 a variation in the radial velocity was discovered thus showing that the star is a spectroscopic binary. The companion is far too faint to affect the visible spectrum by its light, but if it is very massive it may be the souce of the variation in radial velocity observed. If this is so, this is the first spectroscopic binary ever discovered visually.

Altogether, τ Tauri is a most remarkable and important system. Its occultations should on no account be neglected in the future and at least occasionally it should be examined on exceptionally good nights with the largest refractors.

[NOTE—Since the above was written, Mr. Burnham writes to me as follows: "In looking over my Lick Observatory Observations I found that I put τ Tauri down a close pair on Oct. 11, 1888, with the 11-inch, eleven years before the Hough occultation. This observation was overlooked and, so far as I can find, never repeated. In my measures of the distant star in 1900 I infer that the conditions did not warrant my saying any thing about the close pair. The most obvious explanation of failures to see the small star is that it is in rapid motion and much of

the time too close for any instrument. The only thing to do is to examine it at short intervals when the seeing is good enough for a pair both close and unequal."]

The Flower Observatory, March 17, 1910.

HALLEY'S COMET AND THE CHURCH.

JOHN CANDACE DEAN

FOR POPULAR ASTRONOMY.

The article in the April number of POPULAR ASTRONOMY on Calixtus III and Halley's Comet is an interesting collection of information bearing on the subject.

When Halley's Comet appeared in 1456 it was a magnificent celestial object, with a tail extending more than a third of the

Medal distributed by the monks to avert misfortune during the appearance of the great comet of 1680.

way across the heavens. Three years before, Constantinople had fallen into the hands of the Turks. Simultaneously with the appearance of the comet, Mohammed II with his victorious army had crossed the Hellespont and threatened to overrun all Europe. Pope Calixtus III attempted to organize a crusade against the Turks, but, being physically weak and mentally incompetent, he failed to obtain necessary support. He was of the Borgia family and was great uncle of the notorious Lucretia and Caesar Borgia. It was this Pope who is said to have issued a bull against the comet. While he may never have issued such a bull, contemporaneous history appears to agree that he did order the Ave Maria repeated three times a day in-

stead of twice and to the prayer was added, "Lord save us from the devil, the Turk and comet." He also ordered the church bells rung three times a day, which was the beginning of the present practice.

Soon the horrid comet began to wane and the Turks were checked by Hunyada at Belgrad, but there is no historical record that Satan suspended his work.

When the great comet of 1680 and 1681 appeared, medals were struck by the church and distributed by the monks as amulets to avert misfortune from the malign influence of the comet. One of these medals is shown in the accompanying cut. On the obverse side is a representation of the comet with the dates of its appearance. On the reverse side is a German motto which means, "This star threatens evil things; trust in God who will turn them to good." The large Roman capitals in the motto, M. D. C. L. V. V. V. V. V. V. I., if used as numerals and added together make 1681, the year of the comet's visit.

Astrology, at that time, in a large measure governed belief and in the present state of scientific knowledge it is difficult to comprehend the horror once inspired by the appearance of large comets.

There seems to be a concerted effort to rewrite the history of the attitude of the Popes towards science. In the January number of "Knowledge" (London) Rev. Jos. W. Brady says: "It is a threadbare fact of history that Galileo was never accused of heresy, but only bidden to keep provisional and precautionary silence about a theory so new and startling that it *seemed* to be dangerous to faith. Governments every day follow the same policy in political matters."

In a pamphlet under the title "*La Legende Tragique de Jordano Bruno*," by Theophile Desduits, an elaborate attempt has been made to prove that Bruno did not suffer death by order of the Inquisition.

1005 N. Pennsylvania St.,
Indianapolis, Ind.

A GREAT OPEN-AIR TELESCOPE.*

PROFESSOR S. A. MITCHELL.

A giant telescope has been erected in Germany, having for its main purpose the making of astronomy popular through

* *Scientific American.* January 29, 1910.

exhibitions to the public of the heavenly bodies. The United States has repeatedly followed Germany in her advances along scientific lines, and here would be a splendid opportunity to emulate her by the erection of a great public telescope (say) in New York city.

A contrast of this new German telescope at Treptow (near Berlin) with the highest development of American manufacture proves of the greatest interest. In the Yerkes telescope (see *Scientific American*, December 25th, 1909) we have a great instrument given over to exact research, handled by a corps of expert astronomers, leaders in their special lines of work. Professor E. E. Barnard is there with his keen eye for the measurement of the positions of comets, star clusters, etc., for the depicting of slight planetary details, or with the help of the photographic plate for the portrayal of Mars on a large scale. The greatest living authority on double stars, Professor S. W. Burnham,

spends two nights each week with the great 40-inch refractor. The director, Professor E. B. Frost, takes care of the spectroscopic side of astronomy by photographing the spectra of stars for the determining of their motions in the line of sight, and by day time the telescope is made use of to learn of interesting phenomena about the Sun. This great telescope is a model of engineering perfection with its great tube and massive parts, rising floor and rotating dome. It is mounted in what is known as the equatorial form.

But how different is the Treptow telescope! Erected with

other purposes in view, it is not necessary to have expert scientists to keep the telescope employed almost every hour during the day and night; constructed under a different plan, it is unnecessary to have a great elevating floor inside of a huge rotating dome, for in fact, the dome is done away with and the telescope is used in the open air! This then brings something radically new in the old science of astronomy, something entirely different in the construction of a great telescope. And this new form of instrument has many points in its favor that make it a most interesting telescope.

The director of the Treptow Observatory, Dr. F. S. Archenhold, by his radical ideas came into opposition with the German scientists who ridiculed the idea of placing in the open air with no protection from the wind a great tube 68 9/10 feet in length, seven feet longer than the Yerkes telescope (62 feet). But undaunted, Dr. Archenhold persevered and finally succeeded in collecting sufficient funds for the erection of the largest telescope in the world. And this, too, in scientific Germany!

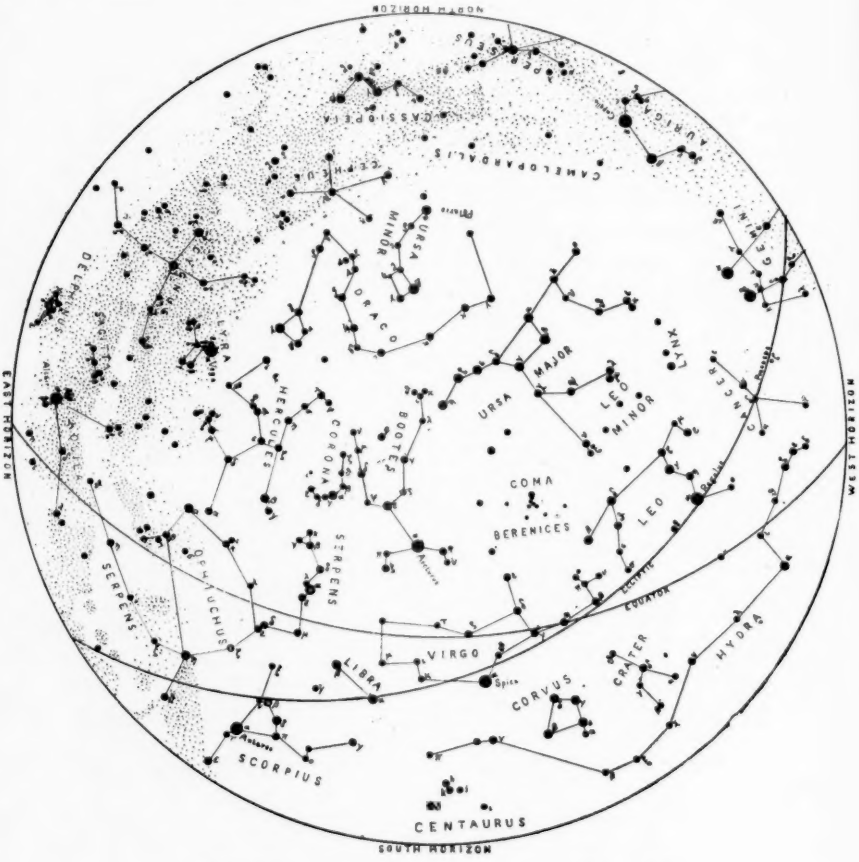
The old equatorial form of mounting was departed from, for this requires that the eye-end of the telescope be raised through a vertical distance approximately half the length of the telescope tube in viewing a star overhead and one near the horizon. This necessitated a very expensive elevating floor run by electric motors (*Scientific American*, December 25th, 1909). By swinging the telescope tube in a great fork, and employing suitable counterpoises. Dr. Archenhold was able to have the eye-piece near the center of motion, and run the telescope tube upward into the air. The details of this will be readily seen by referring to the illustration. This eliminated the rising floor and saved many thousands of dollars. The low forked mounting with its heavy movable parts placed on a solid concrete foundation insured a stable instrument, and as the whole construction had no great height, it became possible to house the telescope by turning the long telescope tube into a horizontal position and pulling over it a cheap portable house. By using the telescope in the open air it became possible to entirely eliminate the great dome, and thereby save again more thousands of dollars. The result of these plans was that Dr. Archenhold was able to build the completed instrument for the modest sum of $62,500. Of this sum $11,500 was spent for the lens, which was made of the celebrated Jena glass ground by the old established firm of Steinhiel, in Munich. The lens is 27 inches in diameter, and is an excellent one.

The radical departure from old-established forms in eliminating the dome has many points in its favor besides the mere saving of money, and also many drawbacks. As is well known to astronomers, the temperature of the night air is continually falling (especially in the early part of the night), and it is impossible to have the air in the interior of the dome at the same temperature as the outside air. This causes the heated air to pour out through the slit of the dome, and also produces currents of air in the interior of the telescope tube itself. All of this makes "bad seeing," and a distortion of the telescopic image—the bane of the existence of the professional astronomer. Dr. Archenhold's plan of doing without a dome eliminates most of the effects of air currents, for there is no "dome effect," as astronomers call it, and the air in the telescope tube quickly takes the temperature of that outside. Here, then, is a decided advantage. But unfortunately the telescope being in the open air makes it the sport of every passing wind, and even a slight wind is apt to set up a vibration in the telescope, especially so when the tube is so long as in the Archenhold telescope, which is supported not in the middle, as in the ordinary telescope, but entirely at one end. Though the vibrations may be small and imperceptible to the eye, still when the telescope is pointed at a fixed star the immense magnifying power of the long telescope would make even the slightest tremors readily visible and would spoil the use of the instrument for accurate work. It would seem that for the important researches of the exact astronomer the open-air telescope would be a failure, but for public exhibitions only it is another story. The absence of dome and rising floor eliminates a great amount of the expense, and the modest amount of the popular subscriptions can be all put up into the construction of a telescope, thus obtaining a much larger instrument. The telescope is raised and a star located by means of a 6½-horse-power electric motor. In order to keep the telescope pointed correctly at the celestial object, it is necessary to drive the telescope to make it move from east to west, otherwise owing to the Earth's rotation the object would quickly move from the field of the telescope. In the Treptow telescope both observer and instrument must be moved, and the details of how this is done by a ½-horse-power motor regulated by clockwork can be seen in the smaller illustrations.

PLANET NOTES FOR JUNE, 1910.

Mercury is morning star and will be visible toward the east about an hour before sunrise from June 18 to 25.

Venus is also morning star and easily seen toward the east any morning.



THE CONSTELLATIONS AT 9:00 P. M. JUNE 1, 1910

She has waned in brilliancy during the past two months but is still very conspicuous, far exceeding any of the stars in brightness. Venus will be in conjunction with the Moon and only a little way north of that luminary on the morning of June 4. On the morning of June 5, Venus and Saturn will appear very close together, Venus being only 4′ north of Saturn at $21^h\ 0^m$ Washington mean time. The two planets will hardly be separated by the naked eye and will be visible in the telescope together.

Mars is seen toward the west in the early evening. This planet now is hardly as bright as a first magnitude star. Its motion is eastward from Gemini into Cancer. The apparent diameter of the planet is now only 4″ so that not much can be seen upon it.

Jupiter is brilliant toward the south in the early evening, in the constellation Virgo. It is easy to turn from Jupiter to the splendid double star Gamma Virginis, the nearest star visible to the naked eye in the vicinity of the planet. Jupiter will be at quadrature 90° east from the Sun June 27.

Saturn is morning star and visible toward the east in the neighborhood of Venus. The close conjunction of the two planets on the morning of June 5 has been mentioned above. Saturn will be very close to the Moon on the morning of June 4.

Uranus may be found in the morning with a telescope, in the constellation Sagittarius. For northern observers the altitude of the planet is too low for satisfactory observations.

Neptune is approaching conjunction with the Sun and so is not in good position for study.

Occultations visible at Washington.

Date 1910	Star's Name	Magnitude.	IMMERSION. Washington M.T. h m	Angle from N. °	EMERSION. Washington M.T. h m	Angle from N °	Duration. h m
June 12	46 Leonis	5.8	10 12	88	11 02	327	0 50
20	126 B. Scorpii	6.1	13 09	165	13 45	217	0 36
21	136 G. Ophiuchi	6.3	7 23	115	8 35	284	1 12
21	151 G. Ophiuchi	6.0	10 19	106	11 49	282	1 30
23	248 B. Sagittarii	5.7	14 30	154	14 49	180	0 19
25	35 Capricorni	6.0	18 01	134	18 22	170	0 21

Phenomena of Jupiter's Satellites.

Central Standard Time.

1910	h	m				1910	h	m			
June 1	11	16	I	Tr.	In.	June 13	7	07	II	Tr.	In.
2	8	24	I	Oc.	Dis.		9	37	II	Sh.	In.
	11	46	I	Ec.	Re.		9	50	II	Tr.	Eg.
3	6	55	I	Sh.	In.	14	7	44	III	Sh.	Eg.
	7	59	I	Tr.	Eg.	15	7	25	II	Ec.	Re.
	9	8	III	Oc.	Re.	17	9	29	I	Tr.	In.
	9	9	I	Sh.	Eg.		10	45	I	Sh.	In.
	11	30	III	Ec.	Dis.	18	10	5	I	Ec.	Re.
4	10	27	II	Oc.	Dis.	19	7	28	I	Sh.	Eg.
6	7	1	II	Sh.	In.	20	9	39	II	Tr.	In.
	7	20	II	Tr.	Eg.	21	9	24	III	Sh.	In.
	9	42	II	Sh.	Eg.	22	10	01	II	Ec.	Re.
9	9	16	I	Oc.	Dis.	25	8	31	I	Oc.	Dis.
10	7	36	I	Tr.	In.	26	7	08	I	Sh.	In.
	8	50	I	Sh.	In.		8	07	I	Tr.	Eg.
	9	51	I	Tr.	Eg.		9	23	I	Sh.	Eg.
	10	18	III	Oc.	Dis.	28	8	04	III	Tr.	In.
	11	04	I	Sh.	Eg.	29	7	24	II	Oc.	Dis.
11	8	10	I	Ec.	Re.						

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., Transit of the Satellite; Sh., transit of the shadow.

COMET NOTES.

Comet *a* 1910.—Letters have been received at this Observatory from Professor E. B. Frost, Director of the Yerkes Observatory, giving the following observations by Professor Barnard:—

Comet *a* 1910 was observed March 12, 1910, at $16^h\ 56^m$ Central Standard Time, in

R. A. $22^h\ 24^m\ 39^s$ and Decl. $+15°\ 37.'3$ (1910.0).

"The comet was of the ninth magnitude, strongly condensed, possibly to a very faint nucleus. No tail noticed."

A photograph of the same comet was obtained at dawn on March 14. No tail was shown on the plate with an exposure of nine minutes. Photographs made with all three lenses of the Bruce telescope, the exposure being $1^h\ 50^m$, failed to show any trace of the comet reported by Pidoux. These plates show a tail to Halley's comet nearly a degree long.

A photograph of Comet *a* 1910 at dawn on the morning of March 15, the exposure being 35^m, shows a faint tail two degrees long.

Astronomical Bulletin, No. 397,
Harvard College Observatory,
Cambridge, Mass., March 17, 1910.

Second Elements and Ephemeris of Comet *a* 1910.—In view of the probability that comet *a* 1910 will be followed by telescopes of great aperture for several months to come I have derived a second set of parabolic elements based upon a long arc and have prepared from them the accompanying improved ephemeris.

These elements depend upon Professor Hussey's positions of January 24, and February 7, and upon Dr. Aitken's observation of March 13. Although the time intervals between these observations are unequal the corresponding change on the comet's position between successive dates is such as to render the results quite determinate.

Because of the uncertain reliability of the early observations of this comet as indicated by the character of the orbits based upon them, I have not employed positions antedating Professor Hussey's direct micrometer comparison of January 24.

The residuals from the three observations given below furnish strong evidence of the parabolic form of the orbit.

The results follow:

PARABOLIC ELEMENTS OF COMET *a* 1910.

T = 1910 January $17^d.0886$ Greenwich Mean Time.
$\omega = 320°\ 53'\ 17''$
$\Omega = 88\ \ 46\ \ 24$ } 1910.0
$i = 138\ \ 47\ \ 8$
Log q = 9.11030

RESIDUALS. OBSERVED-COMPUTED.

	Jan. 24	Feb. 7	Mar. 13.
$\Delta\lambda \cos\beta$	$+4''$	$+1''$	$-5''$
$\Delta\beta$	$+2''$	$\pm 0''$	$+4''$

CONSTANTS FOR THE EQUATOR.

$$x = r\,[9.87644]\,\sin(322^\circ\ 31'\ 7'' + v)$$
$$y = r\,[9.98141]\,\sin(\ 67\ 41\ 29\ + v)$$
$$z = r\,[9.85630]\,\sin(354\ 31\ 24\ + v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1910	True α h m s	True δ ° ′ ″	Log Δ	Log r
Mar. 16.5	22 27 5.0	+16 21 2	0.37420	0.18694
20.5	22 29 35.0	17 8 50	0.38456	
24.5	22 31 51.5	17 55 51	0.39378	
28.5	22 33 55.1	18 42 15	0.40190	
April 1.5	22 35 44.7	19 28 09	0.40909	0.26153
5.5	22 37 20.6	20 13 44	0.4153€	
9.5	22 38 42.5	20 59 05	0.42082	
13.5	22 39 48.6	21 44 04	0.42548	
17.5	22 40 39.2	22 28 53	0 42946	0.32120
21.5	22 41 13.6	23 13 23	0.43275	
25.5	22 41 30.8	23 57 43	0.43544	
29.5	22 41 30.3	24 41 39	0.43758	
May 3.5	22 41 10.5	25 25 15	0.43921	0.37082
7.5	22 40 30.9	26 8 27	0.44036	
11.5	22 39 30.2	26 50 59	0.44109	
15.5	22 38 7.3	27 32 44	0.44147	
19.5	22 36 21.6	27 13 32	0.44154	0.41326
23.5	22 34 11.8	28 53 12	0.44133	
27.5	22 31 37.0	29 31 34	0.44086	0.43240

Detroit Observatory,
University of Michigan,
March 22, 1910.

R. H. CURTISS.

Photograph of Comet *a* 1910.—The accompanying photograph is reproduced because it shows what can be accomplished by an amateur with a

COMET *a* 1910.
PHOTOGRAPH BY N. BARDEN, EXPOSURE JAN. 27, 1910, 6:15-6:30 P. M.

photographic telescope constructed by himself. This photograph was taken by Mr. Norman Barden of Minneapolis with a telescope constructed and mounted equatorially by himself in two days. The plate was a Lumére Sigma, exposed for 15 minutes on the night of January 27. The negative was intensified and an enlarged positive made from it.

Transit of the Comet of 1819.—In connection with the transit of Halley's Comet on May 18th it might be interesting to draw attention to a brief description of the transit of the comet of 1819 as given in Webb's "Celestial Objects for Common Telescopes." The copy I have is of the third edition published in 1873. On page 38 it is stated that "Comets from the endless diversity of their paths must occasionally pass over the Sun; and the opportunity of such a background would be most valuable for acquiring more information as to their nature. This actually took place, 1819, June 26th; but it was not known till afterwards, when a controversy arose as to whether the stranger had been visible.

Pastorff maintained that he had that day seen on the Sun a round dark nebulous spot with a bright point in the center. Olbers and Schumacher thought there was no ground for supposing it to have been the comet: but most fortunately, the original sketch of Pastorff, which is still in existence, and of which through Dr. J. Herschel's kindness, I have been enabled to give a copy (omitting only an attempt to show the mottled aspect) satisfactorily establishes the accuracy of that unique and most curious observation.

This astronomer has left three volumes of drawings of the solar spots, commencing just in time for our present purpose as that in question is only the third from the beginning. According to his frequent practice, an enlarged view of the most remarkable spots is set beside one representing in somewhat careless proportion the whole disk. The singular contrast between the transparent nucleus and dusky coma is in striking harmony with the spectroscopic discovery of Huggins. This feature, missed or obliterated in the general sketch, is especially delineated in the detailed one; and the whole aspect carefully described in the German annotation 'C is quite hazy, luminous in the center and boiling' (atmosphere unsteady). On the following day is the confirmatory remark that D (going off the limb), and C had vanished. The care with which the strange spot was observed is evident from micrometrical measure of its extent."

Accompanying the above description is a copy of the sketch referred to and which I have not the skill to reproduce. The letter D mentioned is an ordinary sun-spot near the limb and C is the comet.

Bayonne, N. J. JOHN H. EADIE.

Ephemeris of Halley's Comet.

[Continued from page 242].

Greenwich Midnight	α 1910.0 h m s	δ 1910.0 ° ′ ″	log *r*	log Δ	Br.
May 27.5	9 19 07.2	+5 16 20			
28.5	9 29 28.0	4 22 09			
29.5	9 45 57.1	3 37 09			
30.5	9 45 01.9	2 59 23	0.0118	9.6522	570.2
31.5	9 51 01.6	2 27 16			
June 1.5	9 56 10.3	1 59 36			
2.5	10 00 37.1	1 35 34			

Ephemeris of Halley's Comet.

Greenwich Midnight 1910	α 1910.0 h m s	δ 1910.0 ° ′ ″	log *r*	log Δ	Br.
June 3·5	10 04 31.3	1 14 27	0.0371	9.7784	283.9
4.5	10 07 59.1	0 55 43			
5.5	10 11 05.1	0 38 58			
6.5	10 13 52.6	0 23 49			
7.5	10 16 24.2	+0 10 03	0.0611	9.8765	116.7
8.5	10 18 42.5	−0 02 33			
9.5	10 20 49.2	0 14 09			
10.5	10 22 46 4	0 24 54			
11.5	10 24 35.2	0 34 55	0.0838	9.9558	101.1
12.5	10 26 17.2	0 44 18			
13.5	10 27 53.0	0 53 09			
14.5	10 29 23.6	1 01 31			
15.5	10 30 49.5	1 09 29	0.1054	0.0222	67.4
16.5	10 32 11.0	1 17 05			
17.5	10 33 28.7	1 24 23			
18.5	10 34 43.0	1 31 22			
19.5	10 35 54.4	1 38 06	0.1258	0.0789	47.3
20.5	10 37 03.2	1 44 36			
21.5	10 38 09.7	1 50 55			
22.5	10 39 13.8	1 57 05			
23.5	10 40 15.8	2 03 06	0.1453	0.1283	34.4
24.5	10 41 15.7	2 08 58			
25.5	10 42 14.3	2 14 44			
26.5	10 43 11.9	2 20 26			
27.5	10 44 08.9	−2 26 03	0.1639	0.1719	25.8

Halley's Comet.—So much has been said in previous numbers of the magazine about Halley's Comet and the conditions under which it may be seen that, now that the time of its proximity to the Earth is at hand, there is little to say without repetition and we must refer our readers to those previous numbers. The comet has come out from behind the Sun, but at the time of this writing (April 20) it is still so involved in the bright background of the dawn that it is not yet visible to the unaided eye. It was observed this morning soon after it rose with our 5-inch and 16-inch telescopes and could be followed until 5 o'clock. No tail was visible but a very bright fanshaped jet issued from the sunward side of the nucleus and curved backward into where the tail should be if it were bright enough to overcome the skylight.

The nucleus appeared to be of about the same brightness as the comparison star DM 5101, which is given in the Potsdam Photographic Catalogue as of magnitude 7.18. The whole head of the comet was perhaps as bright as a sixth magnitude star, certainly not brighter than the fifth magnitude. Judging from this observation, since the comet has already reached perihelion, it seems that Halley's comet is not going to be as bright as some have predicted and as the public have been led to expect.

On the night of May 18 when the Earth passes the tail of the comet and on the subsequent nights when the comet should appear brightest in the western sky, the Moon near its full will greatly interfere with our view, so that on the whole this apparition of Halley's comet is likely to be somewhat disappointing.

Observing Halley's Comet from Teneriffe.—"Plus loin et plus haut, dans les montagnes d'aspect lunaire, je suis venu observer la comète de Halley. J'etablir un campement à 2700^{m} là on vient jadis Piazzi Smyth et vous

envoye un salut lointain. Jean Mascart". This is the message which comes upon a postcard with the picture of the Meteorological Observatory on Mount Teneriffe. It indicates that Jean Mascart has gone to Teneriffe in order to observe Halley's comet at the high altitude of 2700 meters, and is encamped where the well-known astronomer Piazzi Smyth performed his experiments in 1856.

Radiant Point for Meteors from Halley's Comet. In *Popular Astronomy* Vol. 16, p. 518, I gave the computed radiant point using the provisional elements of Messrs. Cowell and Crommelin in the computation. Since that time the magnificent set of definitive elements by these same astronomers has been published—giving also April 19.^{h}67 as the most probable time of perihelion passage.

Although the distance of the comet from the Earth on May 18—the time when it enters the plane of the Earth's orbit and transits across the Sun—is rather large, yet it is possible we may encounter some outlying meteors on that date. I have therefore computed anew the radiant point from Cowell and Crommelin's above mentioned last elements, having regard to the eccentricity of both the Earth's and the Comet's orbits.

RADIANT.

R. A.	Decl.
$22^{h}\ 58^{m}.5$	$+3°\ 14'$

O. C. WENDELL.

Harvard College Observatory.

Elements of d'Arrest's Periodic Comet.—In the *Bulletin Astronomique* for March 1910 Mr. Gustave Leveau gives elements and an ephemeris o d'Arrest's periodic comet for the opposition of 1910. The perturbations due to the attraction of all the planets except Mercury have been taken account of.

Epoch Sept. 19.0, 1910, Paris m. t.

$M_o = 0°\ 26'\ 38''.87$
$\pi = 320\ 09\ 39\ .53$ } 1910.0
$\Omega = 146\ 22\ 18\ .90$ } 1910.0
$i = 15\ 47\ 28\ .16$ } 1910.0
$\phi = 39\ 33\ 43\ .69$
$\mu = 542''.41170$

Perihelion passage 1910 Sept. 16.0523.

The portion of the ephemeris for May and June is given below. The position of the comet is favorable for its early detection.

Ephemeris of d'Arrest's Comet.

(Computed for Paris noon. From the Bulletin Astronomique. March 1910.)

Date		R. A.			Dec.			log Δ	Aberration Time		$\frac{1}{r^2\Delta^2}$
1910		h	m	s	°	′	″		m	s	
April	30	16	40	12.75	+7	5	17.7	0.0522	9	22.0	0.195
May	1	16	40	5.62	7	18	56.6	0.0477	9	16.2	
	2	16	39	56.72	7	32	35.8	0.0432	9	10.5	
	3	16	39	46.01	7	46	14.8	0.0387	9	4.9	
	4	16	39	33.47	7	59	52.5	0.0343	8	59.4	0.218
	5	16	39	19.09	8	13	28.4	0.0299	8	54.0	
	6	16	39	2.87	8	27	1.5	0.0255	8	48.6	
	7	16	38	44.83	8	40	31.2	0.0211	8	43.3	

Date		R. A.			Dec.			log Δ	Aberration Time		$\frac{1}{r^2\Delta^2}$
		h	m	s	°	′	″		m	s	
May	8	16	38	24.97	+ 8	53	56.4	0.0168	8	38.1	0.243
	9	16	38	3.30	9	7	16.4	0.0125	8	33.1	
	10	16	37	39.84	9	20	30.3	0.0083	8	28.1	
	11	16	37	14.60	9	33	37.3	0.0441	8	23.2	
	12	16	36	47.60	9	46	36.5	9.9999	8	18.8	0.271
	13	16	36	18.88	9	59	26.9	9.9958	8	13.6	
	14	16	35	48.46	10	12	7.6	9.9917	8	8.9	
	15	16	35	16.38	10	24	37.7	9.9876	8	4.3	
	16	16	34	42.66	10	36	56.4	9.9836	7	59.9	0.302
	17	16	34	7.35	10	49	2.8	9.9796	7	55.6	
	18	16	33	30.46	11	0	55.7	9.9757	7	51.3	
	19	16	32	52.05	11	12	34.4	9.9718	7	47.1	
	20	16	32	12.13	11	23	57.8	9.9680	7	43.0	0.335
	21	16	31	30.75	11	35	5.0	9.9642	7	39.0	
	22	16	30	48.00	11	45	55.2	9.9605	7	35.1	
	23	16	30	3.90	11	56	27.4	9.9568	7	31.3	
	24	16	29	18.49	12	6	40.5	9.9532	7	27.5	0.371
	25	16	28	31.81	12	16	33.7	9.9496	7	23.8	
	26	16	27	43.96	12	26	6.1	9.9461	7	20.2	
	27	16	26	55.00	12	35	16.3	9.9426	7	16.7	
	28	16	26	4.97	12	44	3.5	9.9392	7	13.3	0.408
	29	16	25	13.93	12	52	26.9	9.0359	7	10.0	
	30	16	24	21.98	13	0	25.6	9.9326	7	6.8	
	31	16	23	29.19	13	7	58.6	9.9294	7	3.7	
une	1	16	22	35.62	13	15	5.0	9.9262	7	0.6	0.448
	2	16	21	41.38	13	21	43.6	0.9231	6	57.6	
	3	16	20	46.54	13	27	53.7	9.9200	6	54.4	
	4	16	19	51.21	13	33	34.3	9.9170	6	51.8	
	5	16	18	55.47	13	38	44.9	9.9141	6	49.0	0.49
	6	16	17	59.43	13	43	24.4	9.9112	6	46.3	
	7	16	17	3.22	13	47	31.7	9.9084	6	43.7	
	8	16	16	6.93	13	51	6.5	9.9057	6	41.	
	9	16	15	10.68	13	54	7.9	9.9030	6	38.7	0.533
	10	16	14	14.58	13	56	35.5	0.9004	6	36.3	
	11	16	13	18.70	13	58	28.7	9.8978	6	34.0	
	12	16	12	23.17	13	59	47.1	9.8953	6	31.7	
	13	16	11	28.11	14	0	30.3	9.8929	6	29.5	0.577
	14	16	10	33.61	14	0	38.0	9.8905	6	27.3	
	15	16	9	39.79	14	0	9.5	9.8882	6	25.2	
	16	16	8	46.76	13	59	4.7	9.8860	6	23.3	
	17	16	7	54.61	13	57	23.4	9.8838	6	21.4	0.622
	18	16	7	3.43	13	55	5.3	9.8817	6	19.5	
	19	16	6	13.35	13	52	10.3	9.8796	6	17.7	
	20	16	5	24.44	13	48	38.2	9.8776	6	16.0	
	21	16	4	36.80	13	44	29.2	9.8756	6	14.3	0.668
	22	16	3	50.50	13	39	43.2	9.8737	6	12.7	
	23	16	3	56.7	13	34	19.7	9.8718	6	11.1	
	24	16	2	22.39	13	28	18.9	9.8700	6	9.5	
	25	16	1	40.74	13	21	40.7	9.8682	6	8.0	0.715
	26	16	1	0.82	13	14	25.2	9.8665	6	6.5	
	27	16	0	22.69	13	6	32.9	9.8948	6	5.1	
	28	15	59	46.42	12	58	3.9	9.8632	9	3.7	
	29	15	59	12.14	12	48	57.8	9.8616	6	2.4	0.762
	30	15	58	39.91	+12	39	15.3	9.8601	6	1.1	

VARIABLE STARS.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time beginning with noon. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours, etc. For stars marked with an * alternate minima are given; ** every third minimum; † every tenth minimum.]

	d	h
SY Androm.		
June	19	17
*U Cephei		
June	3	14
	8	13
	13	13
	17	13
	23	12
	28	12
*Z Persei		
June	1	17
	7	19
	13	22
	20	01
	26	04
RY Persei		
June	4	15
	11	12
	18	9
	25	5
**RZ Cassiop.		
June	2	14
	5	4
	9	18
	13	8
	16	22
	20	12
	24	3
	27	17
*ST Persei		
June	6	4
	11	12
	16	19
	22	2
	27	9
RX Cephei		
June	13	2
*Algol		
June	3	10
	9	4
	14	22
	20	15
	26	9
**RT Persei		
June	1	22
	4	11
	7	0
	9	13
**RT Persei		
June	12	2
	14	15
	17	4
	19	18
	22	7
	24	20
	27	9
	29	22
λ Tauri		
June	3	16
	7	15
	11	14
	15	12
	19	11
	23	10
	27	9
*RW Tauri		
June	3	12
	9	1
	14	14
	20	3
	25	16
*RV Persei		
June	3	21
	7	20
	11	19
	15	18
	19	16
	23	15
	27	14
RW Persei		
June	7	5
	20	10
RS Cephei		
June	6	14
	19	0
*RY Aurigæ		
June	2	16
	8	3
	13	14
	19	1
	24	12
	30	23
*RZ Aurigæ		
June	1	14
	7	15
	13	16
	19	16
	25	17
*RW Gemin.		
June	4	1
	9	19
	15	12
	21	6
	21	23
*U Columbæ		
June	6	5
	11	19
	17	10
	23	0
	28	14
*RW Monoc.		
June	1	7
	5	2
	8	22
	12	17
	16	13
	20	8
	24	4
	27	23
RX Gemin.		
June	1	16
	13	21
	26	2
**RU Monoc.		
June	1	8
	4	1
	6	17
	9	10
	12	2
	14	19
	17	11
	20	4
	22	20
	25	13
	28	6
	30	22
RY Geminorum		
June	1	11
	10	18
	20	2
	29	9
**R Canis Maj.		
June	2	0
	5	10
	8	19
	12	5
	15	15
	19	1
	22	11
	25	20
	29	6
*Y Camelop.		
June	2	4
	8	19
	15	10
	22	0
	28	15
RR Puppis		
June	5	12
	11	22
	18	9
	24	19
**V Puppis		
June	1	16
	6	1
	10	9
	14	18
	19	3
	23	12
	27	20
†X Carinæ		
June	4	16
	10	2
	15	12
	20	22
	26	8
S Cancri		
June	8	15
	18	2
	27	14
S Velorum		
June	1	14
	7	12
	13	11
	19	9
	25	8
**Y Leonis		
June	2	1
	7	2
	12	4
	17	5
	22	7
	27	8
**RR Velorum		
June	1	19
	7	9
	12	22
	18	12
	24	2
	29	15
*SS Carinae		
June	1	7
	7	22
	14	12
	21	3
	27	17
RW Urs. Maj.		
June	3	5
	10	13
	17	21
	25	5
**Z Draconis		
June	1	9
	5	10
	9	12
	13	14
	17	16
	21	17
	25	19
	29	21
*SS Centauri		
June	1	13
	6	12
	11	11
	16	10
	21	9
	26	8
*δ Libræ		
June	5	9
	10	0
	14	6
	19	8
	23	23
	28	15
*U Coronæ		
June	3	6
	10	3
	17	1
	23	23
*SW Ophiuchi		
June	3	17
	8	14
	13	11
	18	9
	23	6
	28	4

Minima of Variable Stars of the Algol Type.—Continued.

*SX Ophiuchi

	d	h
June	3	11
	7	14
	11	17
	15	20
	19	23
	24	2
	28	5

R Aræ

June	3	11
	7	21
	12	8
	16	18
	21	4
	25	14
	30	0

**U Ophiuchi

June	2	23
	5	12
	8	0
	10	12
	13	1
	15	13
	18	2
	20	14
	23	2
	25	15
	28	3
	30	16

**SZ Herculis

June	1	22
	4	9
	6	20
	9	7
	11	18
	14	4
	16	15
	19	2
	21	13
	24	0
	26	11
	28	22

Z Herculis

June	4	22
	8	22
	12	22

Z Herculis

	d	h
June	16	22
	20	22
	24	22
	28	21

*RS Sagittarii

June	4	19
	9	15
	14	11
	19	7
	24	3
	28	23

*V Serpentis

June	3	8
	10	5
	17	3
	24	2

†RZ Draconis

June	1	14
	7	2
	12	14
	18	3
	23	15
	29	3

**RX Herculis

June	1	11
	4	3
	6	19
	9	11
	12	3
	14	19
	17	11
	20	3
	22	19
	25	11
	28	3
	30	19

*SX Sagittarii

June	3	22
	8	1
	12	5
	16	9
	20	12
	24	16
	28	20

*RR Draconis

	d	h
June	4	6
	9	22
	15	14
	21	6
	26	22

**U Scuti

June	1	1
	3	22
	6	19
	9	16
	12	12
	15	9
	18	6
	21	3
	23	23
	26	20
	29	17

*RX Draconis

June	1	10
	5	5
	9	0
	12	19
	16	14
	20	8
	24	3
	27	22

*RV Lyræ

June	5	22
	13	3
	20	8
	27	12

*U Sagittae

June	1	2
	7	21
	14	15
	21	9
	28	3

Z Vulpeculæ

June	2	15
	7	16
	12	17
	17	19
	22	20
	27	21

SY Cygni

	d	h
June	2	3
	8	3
	14	3
	20	3
	26	4

*WW Cygni

June	2	23
	9	14
	16	5
	22	21
	29	12

ZW Cygni

June	1	22
	6	12
	11	2
	15	16
	20	5
	24	19
	29	9

VW Cygni

June	4	5
	12	15
	21	1
	29	12

*UW Cygni

June	4	10
	11	8
	18	5
	25	3

W Delphini

June	4	14
	9	9
	14	4
	19	0
	23	19
	28	14

RR Vulpeculae

June	4	17
	9	18
	14	19

RR Vulpeculae

	d	h
June	19	20
	24	22
	29	23

RR Delphini

	4	7
	8	22
	13	12
	18	22
	22	17
	27	7

**VV Cygni

June	2	22
	7	8
	11	19
	16	5
	20	15
	25	2
	29	12

UZ Cygni

June	19	19

*RT Lacertae

June	3	12
	8	0
	13	2
	18	3
	23	5
	28	7

**TT Androm.

June	1	13
	7	2
	12	14
	18	3
	23	16
	29	4

21.1909 Andr.

June	3	17
	7	20
	11	22
	16	1
	20	4
	24	7
	28	9

Maxima of Variable Stars of Short Period not of the Algol Type.

Unless otherwise indicated the times of maxima only are given; and the times of minima may be found by subtracting the interval printed in parentheses under the names of the stars.

Maxima of Variable Stars of Short Period not of the Algol Type.-Con'

SX Cassiop.

	d	h
June	2	33

SY Cassiop.

June	4	11
	8	13
	12	15
	16	17
	20	18
	24	20
	28	22

RW Cassiop. (−5 19)

June	15	12
	30	7

SU Cassiop. (−0 22)

June	4	0
	5	23
	7	22
	9	21
	11	19
	13	18
	15	17
	17	16
	19	14
	21	13
	23	12
	25	11
	27	10
	29	8

SV Persei

June	10	2
	21	5

RX Aurigæ (−4 0)

June	4	2
	15	17
	27	8

SX Aurigae

June	1	10
	2	22
	4	11
	6	0
	7	13
	9	2
	10	14
	12	3
	13	16
	15	5
	16	17
	18	6
	19	19
	21	8
	22	20
	25	22
	27	11
	28	23
	30	12

SY Aurigae

June	3	20
	13	23
	24	2

Y Aurigæ

	d	h
	(−0	18)
Jun e	1	7
	5	3
	8	24
	12	21
	16	17
	20	14
	24	10
	28	7

RZ Geminorum (−1 7)

June	2	22
	8	11
	13	23
	19	11
	24	24
	30	12

RS Orionis (−2 0)

June	2	5
	9	18
	17	8
	24	21

T Monoc. (−9 23)

June	22	19

W Geminorum (−2 2)

June	8	7
	16	5
	24	3

ξ Geminorum (−5 0)

June	1	14
	11	18
	21	21

RU Camelop. (−9 12)

June	21	20

V Carinæ (−2 4)

June	6	14
	13	7
	19	24
	26	16

T Velorum (−1 10)

June	3	22
	8	14
	13	5
	17	20
	22	12
	27	3

W Carinæ (−1 0)

June	1	8
	5	17
	10	2
	14	10
	19	19

W Carinae

	d	h
June	24	4
	28	13

S Muscæ (−3 11)

June	1	9
	11	1
	20	17
	30	8

T Crucis (−2 2)

June	2	7
	9	0
	15	18
	22	11
	29	5

R Crucis (−1 10)

June	2	5
	8	0
	13	20
	19	16
	25	12

S Crucis (−1 12)

June	2	18
	7	10
	12	3
	16	19
	21	12
	26	4
	30	21

RZ Centauri

June	1	11
	2	10
	3	9
	4	7
	5	6
	6	4
	7	3
	8	1
	8	24
	9	22
	10	21
	11	19
	12	18
	13	16
	14	15
	15	13
	16	12
	17	10
	18	9
	19	7
	20	6
	21	4
	22	3
	23	1
	23	24
	24	22
	25	21
	26	19

RZ Centauri

June	27	18
	28	16
	29	15
	30	13

W Virginis (−8 5)

June	16	11

V Centauri (−1 11)

June	4	8
	9	20
	15	8
	20	19
	26	7

R Triang. Austr. (−1 0)

June	1	13
	4	22
	8	8
	11	17
	15	2
	18	12
	21	21
	25	6
	28	16

S Triang. Austr. (−2 2)

June	6	22
	13	6
	19	13
	25	21

S Normæ (−4 10)

June	9	22
	19	16
	29	10

RV Scorpii (−1 10)

June	4	1
	10	2
	16	4
	22	5
	28	7

RV Ophiuchi Minimum

June	1	10
	5	3
	8	19
	12	12
	16	4
	19	21
	23	13
	27	6
	30	22

X Sagittarii (−2 22)

June	4	8
	11	9
	18	9
	25	9

Y Ophiuchi

	d	h
	(−6	5)
June	6	17
	23	20

W Sagittarii (−3 0)

June	5	12
	13	2
	20	16
	28	7

Y Sagittarii (−2 2)

June	6	10
	12	5
	17	23
	23	18
	29	12

U Sagittarii (−2 23)

June	3	20
	10	14
	17	8
	24	1
	30	19

β Lyræ (−3 7) (−3 2)

June	6	20
	13	12
	20	18
	27	10

κ Pavonis (−4 7)

June	6	17
	15	19
	24	21

U Aquilæ (−2 4)

June	14	18
	21	19
	28	20

U Vulpeculæ (−2 3)

June	5	17
	13	16
	21	16
	29	15

SU Cygni (−1 7)

June	2	6
	6	2
	9	23
	13	19
	17	15
	21	12
	25	8
	29	4

Maxima of Variable Stars of Short Period not of the Algol Type.

Continued.

	η Aquilae			X Cygni			VZ Cygni			Z Lacertae			X Lacertae	
	d	h		d	h		d	h		d	h		d	h
	(−2	6)		(−6	19)		(−1	1)	June	11	12	June	21	2
June	1	11	June	3	1	June	4	10		22	9		26	13
	8	15		19	11		9	6						
	15	20					14	3		RR Lacertae			SW Cassiop.	
	22	24		T Vulpeculae			18	24	June	2	2	June	2	3
	30	4		(−1	10)		23	20		8	12		7	14
			June	4	1		28	17		14	22		13	0
	S Sagittae			8	11					21	8		18	11
	(−3	10)		12	22		Y Lacertae			27	18		23	21
June	2	7		17	8		(−1	10)					29	7
	10	17		21	19		3	21		V Lacertae				
	19	2		26	5		8	5		(−1	16)		RS Cassiop.	
	27	10		30	15		12	13	June	1	6		(−1	19)
							16	20		6	6	June	1	21
	X Vulpeculae			TX Cygni			21	4		11	6		8	4
	(−2	1)	June	1	19		25	15		16	5		14	11
June	5	24		16	12		29	20		21	5		20	18
	12	8								26	4		27	1
	18	15		VY Cygni			δ Cephei							
	24	23		(−2	14)	June	5	10		X Lacertae			RY Cassiop.	
	V Vulpeculae		June	7	21		10	19	June	4	18		(−7	10)
	Minimum			15	18		16	4		10	5	June	12	22
June	6	23		23	15		21	12		15	15		25	1
							26	21						

Approximate Magnitudes of Variable Stars on April 1, 1910.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn.
χ Androm.	0	10.8	+46	27	13.5 *i*	U Arietis	3	5.5	+14	25	11.8*d*
T Androm.		17.2	+26	26	14.0	X Ceti		14.3	− 1	26	9.6*d*
T Cassiop.		17.8	+55	14	8.2*d*	Y Persei		20.9	+43	50	8.4 *i*
R Androm.		18.8	+38	1	12.0*d*	R Persei		23.7	+35	20	12.4*d*
Y Cephei		31.3	+79	48	12.8*d*	Nov. Per. 2	3	24.4	+43	34	12.2
U Cassiop.		40.8	+47	43	<15	W Eridani	4	7.3	−25	24	10.5*d*
RW Androm.		41.9	+32	8	13.0	T Eridani	3	51.0	−24	20	<12
V Androm.		44.6	+35	6	10.8 *i*	T Tauri	4	16.2	+19	18	10.7 *i*
RR Androm.		45.9	+33	50	11.5 *i*	R Tauri		22.8	+ 9	56	8.5 *i*
RV Cassiop.		47.1	+46	53	9.1 *i*	W Tauri		22.2	+15	49	9.8 *i*
W Cassiop.		49.0	+58	1	10.0*d*	S Tauri		23.7	+ 9	44	10.4 *i*
U Androm.	1	9.8	+40	11	10.0 *i*	T Camelop.		30.4	+65	57	8.4
S Cassiop.		12.3	+72	5	8.4*d*	RX Tauri		32.8	+ 8	9	12.5 *i*
RU Androm.		32.8	+38	10	13.8*d*	X Camelop.		32.6	+74	56	11.7 *i*
Y Androm.		33.7	+38	50	11.2 *i*	V Tauri		46.2	+17	22	12.2 *i*
X Cassiop.		49.8	+58	46	9.8 *i*	R Orionis		53.6	+ 7	59	10.5*d*
U Persei		53.0	+54	20	10.0*d*	R Leporis		55.0	−14	57	8.0*d*
S Arietis		59.3	+12	3	<15	V Orionis	5	0.8	+ 3	58	12.5*d*
R Arietis	2	10.4	+24	35	10.5*d*	T Leporis		0.6	−22	2	12.0
W Androm.		11.2	+43	50	13.3*d*	R Aurigae		9.2	+53	28	8.6 *i*
Z Cephei		12.8	+81	13	12.8*d*	S Aurigae		20.5	+34	4	9.2*d*
o Ceti		14.3	− 3	26	8.8*d*	W Aurigae		20.1	+36	49	11.2 *i*
S Persei		15.7	+58	8	9.5 *i*	S Orionis		24.1	− 4	46	10.8*d*
R Ceti		20.9	− 0	38	11.0*d*	T Orionis		30.9	− 5	32	10.2 *i*
RR Persei		21.7	+50	49	10.0 *i*	S Camelop.		30.2	+68	45	8.5 *i*
RR Cephei		30.4	+80	42	14.2*d*	RR Tauri		33.3	+26	19	11.6*d*
R Trianguli		31.0	+33	50	7.7 *i*	U Aurigae		35.6	+31	59	12.0*d*
T Arietis		42.8	+17	6	9.6*d*	SU Tauri	5	43.2	+19	2	13.5 *i*
W Persei		43.2	+56	34	8.8	Z Tauri		46.7	+15	46	9.0 *i*

Approximate Magnitudes of Variable Stars on Apr. 1, 1910—Con.

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A 1900 h	m	Decl. 1900 °	′	Magn
V Camelop.	5	49.4	+74	30	13.5	T Urs.Min.	13	32.6	+73	56	13.6
Z Aurigae		53.6	+53	18	12.0*d*	R Can. Ven.		44.6	+40	2	11.2*d*
X Aurigae	6	4.4	+50	15	12.0*d*	RR Viriginis		59.6	− 8	43	12.5
V Aurigae		16.5	+47	45	10.8*d*	Z Bootis	14	1.7	+13	59	13.0 *i*
V Monoc.		17.7	− 2	9	11.0 *i*	Z Virginis		5.0	−12	50	12.6*d*
R Monoc.		33.7	+ 8	49	11.3*d*	U Urs. Min.		15.1	+67	15	12.0
S Lyncis		35.9	+58	0	8.6 *i*	S Bootis		19.5	+54	16	13.8*d*
X Gemin.		40.7	+30	23	13.0*d*	RS Virginis		22.3	+ 5	8	11.3 *i*
W Monoc.		47.5	− 7	2	11.4*d*	V Bootis		25.7	+39	18	8.2
Y Monoc.		51.3	+11	22	9.8 *i*	R Camelop.		25.1	+84	17	10.8 *i*
X Monoc.		52.4	− 8	56	8.0	R Bootis		32.8	+27	10	10.6 *i*
R Lyncis		53.0	+55	28	10.8*d*	V Librae		34.8	−17	14	12.0 *i*
RS Gemin.		55.2	+30	40	11.5*d*	U Bootis		49.7	+18	6	10.8*d*
V Can. Min.	7	1.5	+ 9	2	<15	RT Librae	15	0.8	−18	21	12.6 *i*
R Gemin.		1.3	+22	52	12.8*d*	T Librae		5.0	−19	38	10.6 *i*
R Can. Min.		3.2	+10	11	8.6*d*	Y Librae		6.4	− 5	38	12.0
RR Monoc.		12.4	+ 1	17	13.2*d*	S Librae		15.6	−20	2	9.0
V Gemin.		17.6	+13	17	9.8 *i*	S Serpentis		17.0	+14	40	13.0
S Can. Min.		27.3	+ 8	32	9.6 *i*	S Coronae		17.3	+31	44	8.5*d*
T Can. Min.		28.4	+11	58	<15	RS Librae		18.5	−22	33	9.
Z Puppis		28.3	−20	27	13.0*d*	RU Librae		27.7	−14	59	8.8*d*
U Can. Min.		35.9	+ 8	37	9.6 *i*	X Librae		30.4	−20	50	<13
S Gemin.		37.0	+23	41	13.2*d*	W Librae		32.2	−15	51	13.5
T Gemin.		43.3	+23	59	10.5 *i*	S Urs.Min.		33.4	+78	58	8.2 *i*
R Cancri	8	11.0	+12	2	10.6	U Librae		36.2	−20	52	10.8*d*
V Cancri		16.0	+17	36	8.6 *i*	R Coronae		44.4	+28	28	6.0 *i*
RT Hydrae		24.7	− 5	59	8.2	X Coronae		45.2	+36	35	12.5*d*
U Cancri		30.0	+19	14	13.6*d*	R Serpentis		46.1	+15	26	10.6 *i*
X Urs. Maj.		33.7	+50	30	10.6 *i*	V Coronae		46.0	+39	52	9.0*d*
S Hydrae		48.4	+ 3	27	8.6 *i*	R Librae		47.9	−15	56	<13.5
T Hydrae		50.8	− 8	46	9.2 *i*	RR Librae		50.6	−18	1	10.0 *i*
T Cancri		51.0	+20	14	8.2 *i*	Z Coronae		52.2	+29	32	13.0*d*
W Cancri	9	4.0	+25	39	11.2*d*	RZ Scorpii		58.6	−23	50	11.4*d*
X Hydrae		30.7	−14	15	10.2 *i*	Z Scorpii	16	0.1	−21	28	10.8*d*
Y Draconis		31.1	+78	18	8.8 *i*	R Herculis		1.7	+18	38	11.0*d*
R Leo. Min.		39.6	+34	58	10.8*d*	RR Herculis		1.5	+50	46	9.0*d*
RR Hydrae		40.4	−23	34	<14.5	U Serpentis		2.5	+10	12	8.0 *i*
R Leonis		42.2	+11	54	10.0	X Scorpii		2.7	−21	16	9.6 *i*
Y Hydrae		46.4	−22	33	8.0	W Scorpii		5.9	−19	53	<13
V Leonis		54.5	+21	44	12.7*d*	RX Scorpii		5.9	−24	38	<13
R Urs. Maj.	10	37.6	+69	18	8.0 *i*	RU Herculis		6.0	+25	50	10.6*d*
W Leonis		48.4	+14	15	<13	R Scorpii		11.7	−22	42	10.6 *i*
S Leonis	11	5.7	+ 6	0	9.0 *i*	S Scorpii		11.7	−22	39	<14
RX Virginis		59.6	− 5	13	8.8	W Ophiuchi		16.0	− 7	28	<14
R Comae		59.1	+19	20	<14.5	V Ophiuchi		21.2	−12	12	9.0
RW Virginis	12	2.1	− 6	12	7.3	U Herculis		21.4	+19	7	12.0
T Virginis		9.5	− 5	29	12.2 *i*	Y Scorpii		23.8	−19	13	12.0
R Corvi		14.4	−18	42	8.0	SS Herculis		28.0	+ 7	3	9.0 *i*
T Can. Ven.		25.2	+32	3	10.6*d*	S Ophiuchi		28.5	−16	57	<13.5
Y Virginis		28.7	− 3	52	11.8*d*	T Ophiuchi		28.0	−15	55	10.0
T Urs. Maj.		31.8	+60	2	8.6*d*	W Herculis		31.7	+37	32	7.2
R Virginis		33.4	+ 7	32	11 0	R Draconis		32.4	+66	58	7.2
RS Urs. Maj.		34.4	+59	2	8.6 *i*	RR Ophiuchi		43.2	−19	17	13.0
S Urs. Maj.		39.6	+61	38	10.2 *i*	S Herculis		47.4	+15	7	9.6 *i*
RU Virginis		42.2	+ 4	42	11.8*d*	RV Herculis		56.8	+31	22	13.0
U Virginis		46.0	+ 6	6	11.6*d*	R Ophiuchi	17	2.0	−15	58	13.5
RT Virginis		57.6	+ 5	43	8.4	RT Herculis		6.8	+27	11	<14
RV Virginis	13	2.7	−12	38	12.8*d*	Z Ophiuchi		14.5	+ 1	37	12.6
V Virginis		22.6	− 2	39	9.6*d*	RS Herculis		17.5	+23	1	12.6
R Hydrae		24.2	−27	46	8.2*d*	RU Ophiuchi		28.1	+ 9	30	11.0 *i*
S Virginis		27.8	− 6	41	10.6*d*	RT Ophiuchi		51.8	+11	11	9.6

Approximate Magnitudes of Variable Stars on Apr. 1, 1910—Con.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.
T Draconis	17 54.8	+58 14	11.5*d*	T Sagittae	19 17.2	+17 28	10.3 *i*
— Draconis	54.7	+54 14	11.0	TY Cygni	29.8	+28 ?	<13
RY Herculis	55.4	−19 29	<13.5	R Cygni	34.1	+49 58	13.8*d*
V Draconis	56.3	+54 53	14.0	RT Cygni	40.8	+48 32	10.5*d*
T Herculis	18 5.3	+31 0	7.8	TU Cygni	43.3	+48 49	13.6*d*
W Draconis	5.4	+65 56	11.0 *i*	χ Cygni	46.7	+32 40	9.5 *i*
U Draconis	6.8	+66 8	13.0*d*	Z Cygni	58.6	+49 46	8.5
W Lyrae	11.5	+36 38	8.0	S Cygni	20 3.4	+57 42	<14
SV Herculis	22.3	+24 58	<13.5	U Cygni	16.5	+47 35	10.5*d*
T Serpentis	23.9	+ 6 14	1.2*d*	V Cygni	38.1	+47 47	10.2*d*
RY Lyrae	41.2	+34 34	<14	RZ Cygni	48.5	+46 59	13.8*d*
RW Lyrae	42.1	+43 32	<14	R Vulpeculae	59.9	+23 26	8.0
Z Lyrae	56.0	+34 49	10.5*d*	X Cephei	21 3.6	+82 40	12.0*d*
RX Lyrae	50.4	+32 42	<13.5	T Cephei	8.2	+68 5	8.3 i
RT Lyrae	57.8	+37 22	12.6	S Cephei	36.5	+78 10	10.5*d*
R Aquilae	19 1.6	+ 8 5	11.8	S Lacertae	22 24.6	+39 48	10.0 *i*
V Lyrae	5.2	+29 30	11.6	R Lacertae	38.8	+41 51	8 3 *i*
S Lyrae	9.1	+25 50	9.6	V Cassiop.	23 7.4	+59 8	7.5 *i*
RS Lyrae	9.3	+33 15	<13.5	Z Cassiop.	39.7	+56 2	14.0*d*
RU Lyrae	9.1	+41 8	<14	RR Cassiop.	50.7	+53 8	12.6*d*
TZ Cygni	13.4	+50 0	10.8	R Cassiop.	53.3	+50 50	9.2*d*
U Lyrae	16.6	+37 42	9.8*d*	Y Cassiop.	58.2	+55 7	<14

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled by Mr. Leon Campbell of the Harvard College Observatory from observations made at the Vassar, Mt. Holyoke, Swartz, Olcott and Harvard Observatories.

Light Curve of RR Ceti (122.1906.)—Mr. Ladislaw Pračka has recently published new elements of the variable star RR Ceti in the *Bulletin International de l'Académie des Sciences de Bohême* 1909. He finds the star to be a special case of the δ Cephei type, the period being only $13^h\ 16^m\ 21.^s101$. The elements are

Maximum = JD. 2417501.455 Gr. m. t. + $0.^d553022$ E.
Max.—Min. = $0.^d080$. Variation $8.^m2 - 9.^m1$. Color: White.

The light curve rises rapidly to the maximum, falls rapidly for an hour then slowly for eleven hours to the minimum.

New Variable 27.1910 Scuti.—This is the star BD. −4°4548 and was used by Mr. Ichinohe of the Tokio Observatory as a comparison star for the variable 59.1907 Scuti. From 25 observations the range of variation appears to be about one magnitude. It is possibly a short period variable The BD magnitude is $8.^m8$. Its position for 1855.0 is

$$\alpha = 18^h\ 33^m\ 16^s.2 \qquad \delta = -4°\ 12'.9.$$

Three New Variables 29, 30 and 31.1910 Andromedæ.—In *A. N.* 4393 Professor W. Ceraski announces three new variables discovered by Mme Ceraski upon the photographs taken at Moscow. Their positions are

	α 1855.0 h m s	δ 1855.0 ° ′	α 1910.0 h m s	δ 1910.0
29.1910 Andromedæ	1 13 37	+37 56	1 16 11	+38 10
30.1910 "	1 21 00	+35 54	1 23 34	+36 08
31.1910 "	0 36 07	+30 09	0 38 31	+30 24

The first ranges from about 10.7 magnitude at maximum to about $12^m.0$ at minimum; the period is possibly 234 days. It was at a maximum Oct. 10th, 1908.

The second is about ½′ east of the middle point between the stars BD +35°282 and 283. Its brightness varies between about $11.^m3$ and $12.^m0$. Two stars of magnitude 12.0 are found ESE from this star at distances of

1.'5 and 4'. The second of these is probably variable with a small range, —about 0.^{m}3.

The star 31.1910 was found on 19 photographs taken betwen 1906 and 1909, and ranges from 10.^{m}7 to 11.^{m}9. The type of the variable is uncertain, perhaps of short period or irregular.

Observations of Variable Stars.—In the *Bulletin International de l'Académie des Sciences de Bohême* Mr. Ladislaw Pračka, of the Nižbor observatory in Bohemia gives results of his observations of 49 long period variable stars during the years 1905-09.

GENERAL NOTES.

Change of Management of Popular Astronomy. With this number, the ownership and the management of POPULAR ASTRONOMY passes out of my hands. Hereafter it becomes the property of Carleton College, and its management will be in the efficient care of Dr. H. C. Wilson, now director of Goodsell Observatory of Carleton College.

Dr. Wilson needs no introduction to the many readers of POPULAR ASTRONOMY, either at home or abroad. As a contributor and associate editor of this publication for many years he has earned an enviable reputation, as a scholar and as an able practical worker in the science of the stars which he so much loves. In more ways than I can name the subscribers to this magazine will be the gainers for these important changes, now being made, in its responsible management after a period of substantial growth for more than twenty-five years.

In taking leave of the many hundreds of good friends in all parts of the world I say good bye with the best and most cordial thanks of my heart for the wise, constant and timely advice and help in projecting and maintaining this journal for more than a quarter of a century of very eventful astronomical history.

I confidently expect and assuredly hope that these friends and many more will hereafter be found in the ranks of ardent supporters of this publication in its new management which has had, and probably will have, for its distinct aim profound loyalty to the truth from whatever source it may come. If this shall be nobly true, none have worked, or will work, in vain.

WM. W. PAYNE.

Elgin Observatory,
Elgin, Ill.
April 10, 1910.

Mr. Carothers' New Observatory. I have a new Observatory about finished. It will be ready for occupancy by April 1st. The telescope is a six-inch just made for us by the Clarks, mounted on an independent brick pier from the ground up. The tower is three stories high, 16 feet diameter, revolving dome 14 feet in diameter.

W. F. Carothers.

Houston, Texas.

Two Types of Comets' Tails.—That comets' tails are of two distinct kinds has not, the writer believes, been heretofore clearly recognized. In his recent paper on Halley's comet, on page 129 of this magazine, he points out that the tail formed before and that formed after the perihelion passage were

quite unlike, the former taking its origin in the nucleus, and the latter being distinct from it, but enveloping the head. Judged by the photographs of recent comets the former kind is much the more common of the two, and consists usually of a bunch of rays more or less straight proceeding from the nucleus directly away from the Sun. The other kind of tail is well illustrated in the classical representation of the comet of 1811 given in Chamber's Handbook of Astronomy 1889, I, 447, and elsewhere. It is also illustrated in the photograph of the great comet of 1901, in Clerke's History of Astronomy 1902, 343, and in the recent photographs of the comet of 1910*a*, given in the March number of this magazine, and in the Jan.-Feb. number of the Journal of the R. A. Society of Canada.

The enveloping type of tail seems to be much smoother in structure than the type that issues from the nucleus, and it is the kind that seems to have been present in at least three of the five great comets of the last century, namely 1811, 1858 and 1882. In Swift's comet, 1892 I, both types of tail were present at the same time, and in the Harvard Annals, 32, 268, they are distinguished as the inner and outer tail, both types being shown on Plates IX and XIV of that publication. If for convenience of reference we call that part of the nucleus turned away from the Sun its outer pole, then the inner tail takes its origin from the outer pole, and the outer tail by means of jets takes its origin from the inner pole.

WILLIAM H. PICKERING.

Harvard College Observatory.
March 21, 1910.

Ciel et Terre. This Journal has been discontinued as a separate publication and is united with the Bulletin de la Société Belge d' Astronomie.

Publication of the Observatory at Christiania. A publication recently sent out from the University Observatory at Christiania, Norway, gives the details of meridian observations made in the zone 65°-70° of north declination during the years 1897 to 1907. It includes stars down to magnitude 9.5.

Radial Velocity of Polaris. The radial velocity of the binary system in the triple system of Polaris decreased slowly from —11.2 km. per second at 1899.8 to about —17.3 at 1908.7. The velocity observed with the Mills spectrograph at 1909.9 was approximately —15.3km. The minimum has, therefore, been passed, and the radial velocity of the center of mass of the binary system appears to be increasing rapidly. Radial velocity observations of the bright component of the Polaris system, made within the next few months, promise to have unusual weight in the determination of the period of the third member of the system around the center of mass of itself and the binary system.

Lick Observatory Bulletin No. 173, Dec. 31, 1909. W.W. CAMPBELL.

Death of Darius Ogden Mills. The Lick Observatory Bulletin No. 173 records the death of Darius Odgen Mills, on the evening of January 3, 1910, in his eighthy-fifth year. Mr. Mills was the donor of the two Mills spectrographs used in connection with the 36-inch refracting telescope, and the D. O. Mills expedition from the Lick Observatory, University of California, located on the summit of San Cristóbal, Santiago, Chile, is due solely to his generosity. Mr. Mills was a member of the first Board of Trustees appointed

by James Lick to control the construction and equipment of the Lick Observatory, in which duty he gave freely of his time and mature judgment. Mr. Mills' benefactions in support of higher education in its various phases and of organized charity were numerous, and remarkable for their effectiveness.

Note Concerning the Radial Velocity of Procyon. We have radial velocities of Procyon, as determined with the Mills spectrograph, extending over thirteen years. This is one-third the revolution period deduced by Dr. Auwers. As the observed radial velocities do not appear to have varied appreciably in a manner to accord with a period of forty years, more or less, they seem to be in harmony with Dr. Auwers' conclusion that the orbit plane of the system of Procyon is approximately tangent to the celestial sphere. However, it should be stated with some reserve, that our observations appear to show a secondary variation of radial velocity whose double amplitude is probably less than 1.5 kilometers per second, and whose period is about seven years; but observations covering several additional years will be required to place this suspected variation beyond question. W. W. CAMPBELL.

Lick Observatory Bulletin, No. 173.

On the Galactic System. Dr. Karl Bohlin has published a very interesting paper "on the Galactic System with regard to its structure, origin and relations in space" (Kungl. Svenska Vetenshapsakademiens Handlingar. Band 43. No. 10). By diagrams he shows that the known globular clusters lie nearly all in one hemisphere of the heavens and are distributed rather symmetrically with reference to a point *in the Milky Way* in R.A. $5^h\ 40^m$, Decl. $-35°$. This is nearly opposite to the point toward which the solar system is moving.

The bright nebulae on the other hand are most of them away from the Galaxy, while the planetary nebulae appear to be more numerous in the Milky Way, and are distributed in all galactic longitudes. Dr. Bohlin regards the planetary and annular nebulae as resulting from the formation of globular hollow shells of tenuous matter, which shells in many instances have broken in at the poles and formed rings with central nuclei. The paper is illustrated with a number of photographs of planetary and annular nebulae.

Amateur Speculations. A correspondent from St. Paul, Minn., offers the suggestions quoted below, which might explain many puzzling things in astronomy, if only we could consider the action and effects of matter distributed through enormous cosmic spaces to be analogous to that with which we are familiar in our laboratory experiments. No doubt there are vast spaces in which inconceivable quantities of matter remain uncondensed into stars, but this matter is under such very different conditions from those under which our experiments can be performed that it is unsafe to draw conclusions as to its effect upon light waves.

"On my library table stands a gas lamp, fitted with a mantle, plain glass chimney, and a white glass shade. Also on this table is a reading glass. If this glass be placed so that the rays from the lamp fall upon the lens, we see not only a reflection of the lamp in the glass, but also an image of the lamp projected into space. There is nothing on which these light rays fall to make them visible; the light image simply stands out in space. If a hand mirror be placed under the reading glass the light image becomes larger, more brilliant, and is projected to a greater distance. A screen may be so placed as to hide

from view both the lamp and its reflection in the glass, and yet we can still see the light image. If the glass is placed so as to receive the direct rays of the Sun, an image of the Sun will be projected into space.

"Away out in starry space there exist great oceans of transparent invisible gas, millions of miles in extent. Occasionally vast gaseous billows assume shape and position to become in effect as reading glass and mirror, and project into space, at an angle favorable to earthly view, an image of the Sun or of some other star, and this image blazes forth as a new star, a brilliant Nova. When the image-producing media gradually assume less favorable position, the new star wanes and disappears. Surely a simple explanation of the phenomenon of temporary stars. And why need the Aurora remain longer a mystery? And why may not the sun-dogs be caught?

"But listen. The media which give us the Novas, the star ghosts, may in fact be sky veils; they may constitute the dark portions of the firmament. And the rending or shifting of one of these veils may at any time reveal a hitherto unknown star, or even group of stars, which may soon be again obscured and go on the list of temporary stars, or they many remain permanently in view. And it may easily come to pass that the shifting of these veils may startle the world by causing the temporary or permanent disappearance of some well known star or group of stars." A. P.

655 Dayton Ave., St. Paul, Minn.

The Spectra of the Major Planets. Bulletin No. 42 of the Lowell Observatory contains results of recent study of the spectra of the planets by means of photographs taken upon specially sensitized plates. A combination of sensitizing dyes has been found "which renders the sensitiveness of the commerical dry plate fairly uniform into the red as far as to wave-length 7000, beyond which point it drops rather rapidly, but is sufficient at A to faintly record that line in the prismatic solar spectrum. This plate has accomplished much by bringing under observation a new region of the spectrum—one peculiarly susceptible to selective absorption by planetary atmospheres. With the aid of it the spectra of Jupiter, Saturn, Uranus and Neptune have now all been photographed with greater extension into the red than any previous photographic or visual observations, and a number of lines and bands have been discovered, "The method of sensitizing consists in bathing a clean-working commerical plate for three or four minutes in a bath made up as follows:

Dicyanin (stock solution)	45 minims
Pinacyanol " "	28 "
Pinaverdol " "	70 "
Ammonia	120 "
Water	7 to 8 ounces

"Upon removal from this bath, the plate is washed in water or rinsed in alcohol and dried in a current of air. The dicyanin is the dye which sensitizes to the extreme red, but it does this at the expense of speed. Thus in cases where the light is very weak, as is the case with Neptune, the bath is used without the dicyanin or, better, with homocol substituted for it. A plate bathed in this manner records the spectrum to a short distance below *B*. If the dyes be diluted with equal parts of water and alcohol, instead of water alone, a somewhat cleaner plate results when rinsed in alcohol; but in this instance it is slightly less sensitive to the extreme red. A vigorous and quick-working developer seems to be best suited to the plate. All manipulation of the plates is carried on in darkness and at a temperature of about 21 degrees Centigrade.

Seed plates have been used almost exclusively, the "27 gilt edge" or the "23". The latter, owing to its finer grain, has advantages in cases where its longer exposure is no obstacle."

Reproductions of the spectra of the Moon, Jupiter, Saturn, Uranus and Neptune are shown side by side, revealing plainly a progressive strengthening and increase in number of the absorbtion bands which are found in the spectra of the planets from Jupiter outward from the Sun.

"Comparison shows that all the bands found to be present in the spectra of the planets Jupiter, Saturn and Uranus, exist with increased intensity in the spectrum of Neptune, excepting the band at 646 $\mu\mu$ in the spectrum of Jupiter, which may be peculiar alone to that planet. Certainly it is that it has not gained strength from Jupiter on, as the other bands have done."

Photographs of Jupiter.—In the Fourteenth Report of the Jupiter section of the British Astronomical Association, which has just come to hand, are several reproductions of photographs of Jupiter taken by Mr. J. H. Reynolds with a reflector of long focus. These photographs are interesting, in that, although they show very little of the finer details of the belts upon the planet, they show the general aspect of the planet and relative intensity of the belts and zones much better than drawings made by hand. It requires great skill in draughtsmanship not to represent vague and illusory markings, seen only in the best moments of definition, with far too great distinctness as compared with the more prominent markings about which there is no question and which are therefore not emphasized enough. Concerning these photographs Mr. Reynolds says:

"The instrument with which these photographs were taken is a 24-in. reflector of 38 feet focal length, mounted in conjunction with a cœlostat of 28-in. aperture. The primary image was enlarged by means of a Cooke Barlow lens to an equivalent focal length of from 80 to 120 feet. Air disturbance is as might be expected the great difficulty in this kind of work, and the plan was adopted of taking several on the same plate, with the result that, on the average, one out of four was found to be of fair definition. Even then the definition was not critical and for detail hand drawings must be relied upon. In comparing photographs taken near opposition in 1908 and 1909, it was found, however, that the photographs were valuable in registering the general appearance of the disk which is apt to be misrepresented in hand drawings. A notable difference between the two apparitions was in the contrast between the belts and zones. In the 1908 photographs the equatorial belts were well marked and bordered north and south by bright zones, whereas in 1909, the contrast was less strongly marked, and the north temperate zone had weakened considerably in brightness, some of the negatives showing an almost even shading between the equatorial zone and the north polar regions. Both the north and south polar regions also appeared conspicuously darker in 1908 than 1909. A possible explanation of these changes seems to be suggested by some spectroscopic work undertaken in April and May of the present year (1909). Photographs of the Jovian and solar spectra taken with the same instrument and compared show a considerable falling off of the ultra violet region in the former. It is evident, therefore, that the Jovian atmosphere is analogous to ours in its absorption of the ultra-violet portion of the spectrum.

"It has been recognized for some time past that the belts are probably at a lower level than the zones, and it seems likely that the actinic effect of the masses of vapor varies according to the depth of immersion in the planet's

PLATE XI.

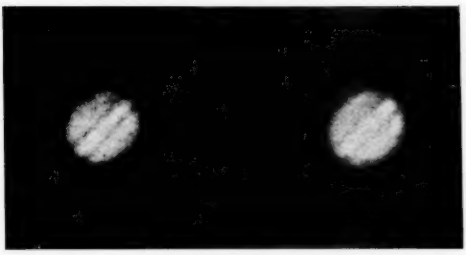


FIGURE 1.—Opposition, 1908.

FIGURE 2.—Opposition, 1909.
Showing difference in general aspect.

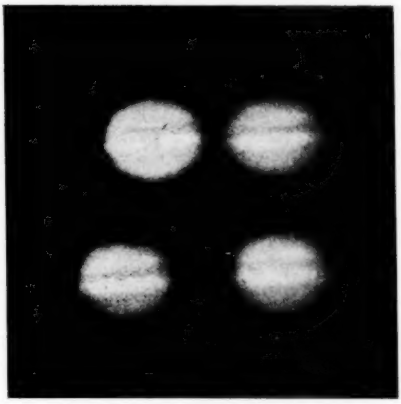


FIGURE 3.—Jupiter, 1909, April 3, 9:15 p. m.
Showing variation of tone in the belts.

PHOTOGRAPHS OF JUPITER IN 1908 AND 1909.

By MR. J. H. REYNOLDS.

Showing changes in relative intensity of the shadings.

atmosphere. A photograph taken on April 3 (Fig. 3), shows a marked decline of tone in the S. equatorial belt from east to west, thus suggesting a corresponding variation in the depth of the belt. In the photographs the bright equatorial zone seems to stand out on the limb beyond the belts. Although this is due in a great measure to irradiation, it is so conspicuous, even on underexposed negatives, that this explanation does not seem to account for it altogether. A further series of spectrographs, which I hope to take next year, using an equivalent focal length of 100 feet may throw some more light on the question."

Wesley's Classified Catalogue just issued contains a list of 3641 books and pamphlets on astronomical subjects. This list includes the libraries of Captain W. Noble, E. Crossley, Miss A. M. Clerke and A. A. Common, all well-known astronomers. The catalogue will be sent post free on receipt of 25 cents, as owing to the great expense in its production the publishers are unable to send it gratis to all applicants. Send to William Wesley & Son, 28 Essex Street, Strand, London W. C., England.

Spectroscosic Determination of Solar Parallax.—The Annals of the Cape Observatory, Vol. X, Part 3, contains the results of an interesting piece of spectroscopic work, carried out at the Royal Observatory, Cape of Good Hope in the years 1906-8. It is no less than a determination of the constants of aberration of light and the solar parallax from the measurement of spectrograms of the seven bright stars—α Tauri, α Orionis, α Canis Minoris, β Geminorum, α Boötis, α_2 Centauri and α Scorpii. The total number of plates measured was 302.

For the solar parallax the mean of the results from the seven stars is

$$\pi = 8.''800 \pm 0.''006.$$

For the constant of aberration the same measures yield the result

$$20.''473 \pm 0.''015.$$

Occultation of the Shadow of Jupiter's Satellite I.—In the same report mentioned above is an account of the occultation of the shadow of Jupiter's Satellite I by the satellite itself while in transit across the planet's disk. This was observed by Messrs. Scriven Bolton and Ellison Hawks on Feb. 28, 1909. Mr. Bolton's note is as follows: "Satellite I and its shadow were seen to enter upon the disk, and were watched till mid-transit. The center of the shadow slightly preceded the center of the satellite and this is in agreement with the N. A. which gives the ingress bisection of the shadow one minute earlier than that of the satellite."

Mr. Ellison Hawks observed the phenomenon throughout and gives this account of it:

"The times were not quite as predicted.

First contact of shadow of I - -	$9^h\ 14^m\ 40^s$
First contact of satellite I - -	$9^h\ 15^m\ 0^s$

The shadow was then slightly preceding the satellite though part of the shadow overlapped the shadow. As the transit progressed, the satellite gained on the shadow, until about $10^h\ 30^m$ the two disks were almost superimposed, the shadow, however, being a little farther south than the satellite. Both shadow and satellite quitted Jupiter's disk simultaneously, and the observed time was $11^h\ 33^m$, but accuracy could not be upheld as clouds were in evidence and troublesome."

Mercurial and Lunar Perturbations.—The perihelion point of Mercury moves forward along the plane of the planet's orbit by 41.54" per century more than can be accounted for by planetary influences. There has been an immense amount of investigation bestowed upon this subject, ever since Leverrier's demonstration. An intra-Mercurial planet has been postulated, named, and at one time was thought to have been seen. Upon Professor Newcomb's very exhaustive study of the subject, he arrived at the conclusion that no known planetary body or bodies did or could produce the observed effect on the motion of Mercury. The cause of sundry unaccountable perturbations must be looked for elsewhere; and with this in view, he established tentatively, a slight vari-

ation in Newton's law. That is, that the square of the distance is not the exact amount of inverse variation, but that the exponent is, in reality, a slight fraction more than 2, namely 2.0000001574.

Now on the other hand, in lieu of upsetting the fundamental law, as laid down by its discoverer, may we not first investigate every other possibility in an effort to attribute the unique perihelion motion to a simpler cause? To elucidate, may we not look to the Sun itself for an unknown factor, exercising an influence upon the motion of Mercury which does not extend much beyond that planet's orbit? And may not that factor be the moving magnetic solar poles? The hypothesis depends upon the recognition of magnetic poles on the Sun, a point easily conceded, and the assumption that such poles do move; having in mind the well known terrestrial analogy. That the slow and regular movement of magnetic centers upon the Sun, should have the observed effect upon the revolution of the planet lying nearest the Sun, does not seem highly unlikely. The location of the magnetic poles, their movement and the amount of influence exerted upon Mercury, are problems awaiting solution.

Referring to a lunar problem, a note from Professor Newcomb's "Investigations of Inequalities in the Motion of the Moon," 1907, published in the Carnegie Institute, Washington, reads as follows: "The representation of the Moon's mean longitude during the period from 1650 1875 showed a discrepancy between existing theory and observation which might be indicated by a term having a period of two or three centuries, and a co-efficient of about 15″. There must be some term of long period still undiscovered in the actual mean motion of the Moon." The question then occurs, might not the "term of long period still undiscovered" be looked for in the motion of the Earth's magnetic poles. There is a great deal of accurate observation on record about the motion of the magnetic poles during the last three or four hundred years, westward from Nova Zembla to a point near Melville Sound. An analogy may be established between the influence of terrestrlal magnetic polar motion on the Moon's movement, and the influence of the Sun's magnetic poles on the journey of Mercury's perihelion.

N. W. MUMFORD.

New York, Dec. 2, '09

Stars whose Radial Velocities Vary.—In the *Lick Observatory Bulletin* No. 173 is given the following list of stars with variable radial velocity, recently discovered in the measurement of spectrograms taken at Lick Observatory and in Chile.

Star	Mag.	α h	m	δ °	′	Extreme Range k	k	Plates taken	
V Piscium	4.7	1	14.0	+ 16	44	— 1.4	+ 22.2	6	1908-9
π Ceti	4.4	2	39.4	— 14	17	+ 7.0	+ 20.6	7	1903-8
κ Persei	4.0	3	02.7	+ 44	29	+27.2	+ 32.4	7	1899-1909
b Persei	4.5	4	10.7	+ 50	03	— 3.5	+ 52.5	4	1903-9
δ Canis Maj.	2.9	7	04.3	— 26	14	+32.8	+ 35.8	15	1903-9
φ Hydræ	3.9	9	09.2	+ 2	44	—20.	+ 7.	6	1903-9
ρ Leonis	3.8	10	27.5	+ 9	49	+35.3	+ 58.0	6	1902-8
α Urs. Maj.	2.0	10	57.6	+ 62	17	—10.4	— 3.9	12	1897-1909
π 8 Virginis	4.6	11	55.7	+ 7	10	—20.6	+ 17.8	3	1909
η 8 Corvi	4.4	12	26.9	— 15	38	—12	+ 18.8	4	1909
β Crucis	1.5	12	41.8	— 59	8	+ 6	+ 25	9	1904-9
D.C. 6501	5.0	13	30.3	+ 37	52	+ 2.1	+ 13.7	4	1905-9
η Centauri	2.5	14	29.2	— 41	43	—11	+ 6	7	1904-7
α Lupi	2.5	14	55.2	— 46	57	0.0	+ 17	10	1904-9
κ Centauri	3.4	14	52.6	— 41	52	+ 4.4	+ 17.1	10	1904-8
χ Ophiuchi	4.9	16	21.2	— 18	14	—11.4	+ 22	3	1896-1902
γ Apodis	3.9	16	18.1	— 78	04	+ 1.9	+ 8.2	7	1904-9
υ Scorpii	2.8	17	24.0	— 37	13	— 2	+ 38	8	1904-7
o Draconis	4.9	18	49.7	+ 59	16	—20.2	+ 5.4	4	1902-9
υ Draconis	4.9	18	55.6	+ 71	10	—13.	— 2.8	6	1907-9
η Lyræ	4.5	19	10.4	+ 38	58	—13.2	— 2.4	4	1906-9
τ Draconis	4.7	19	17.5	+ 73	10	—34.0	— 27.1	6	1904-9
ϵ Draconis	4.0	19	48.5	+ 70	01	— 0.1	+ 5.8	7	1898-1909
δ Cephei	4.2	20	27.9	+ 62	40	—13.7	+ 7	8	1902-8
σ Cygni	4.2	21	13.5	+ 38	59	—11.7	— 1.6	6	1902-8
ξ Capricorni	4.1	21	20.9	— 22	51	— 4	+ 5.1	7	1899-1908
D.C. 9701	4.6	22	09.5	+ 39	13	—14.4	— 8.9	6	1906-9